OCTOBER, 1960
No. 249

ASTM Bulletin

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American Society for Testing Materials
RESEARCH AND STANDARDS FOR MATERIALS

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$$S = \frac{Ec}{2\sqrt{N}} + Se$$

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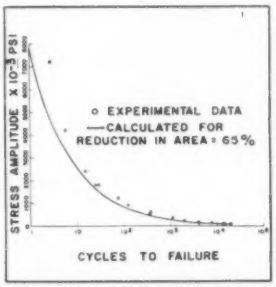
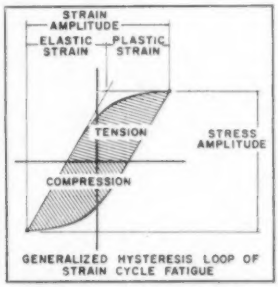
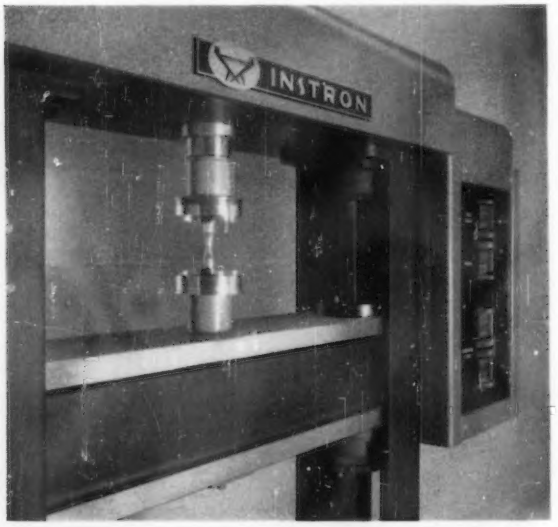


Typical curve (for 1018 carbon) shows correlation between Instron data (dots) and formula (solid lines).



Generalized hysteresis loop of strain cycle fatigue.



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ASTM BULLETIN

October 1960 **Number 249**

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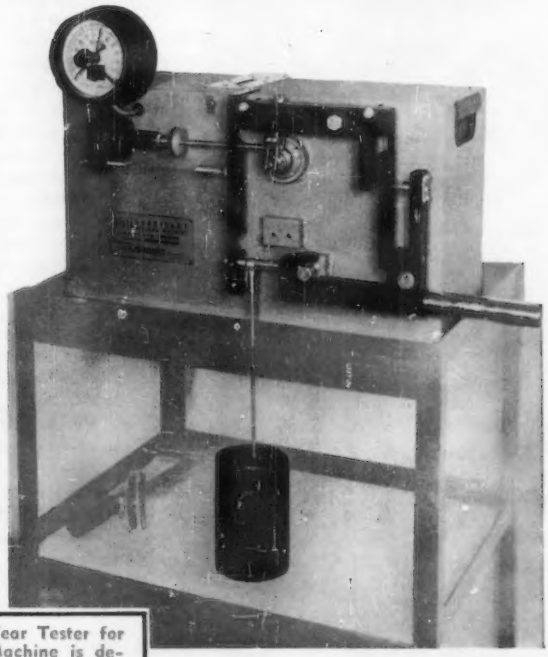

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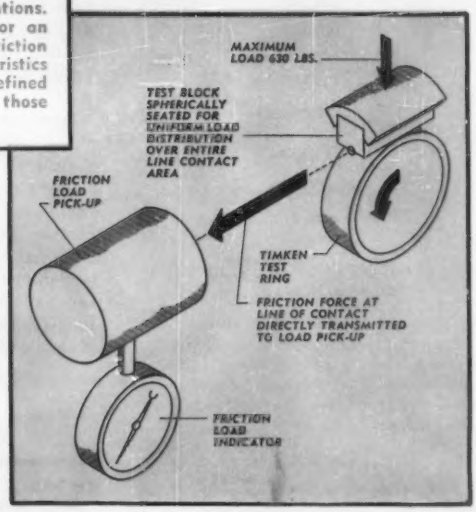
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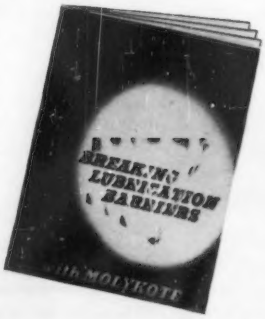

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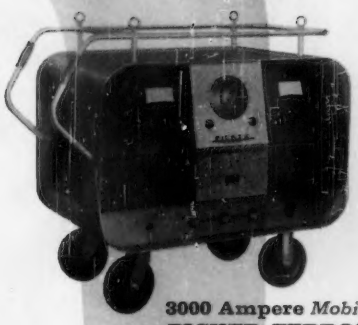

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ASTM BULLETIN

Research and Standards for Materials

Number 249 October 1960

Marshall Named Executive Secretary

Van Atta Assumes Post of Treasurer

THOMAS A. MARSHALL, JR., has been elected ASTM executive secretary by the Society's Board of Directors, effective October 15, 1960. Mr. Marshall was senior assistant secretary of The American Society of Mechanical Engineers.

Fred F. Van Atta, formerly assistant secretary of ASTM, was elected to the post of treasurer with responsibility for the business operations of the Society. Robert J. Painter, until recently executive secretary and treasurer, who has vacated these positions for health reasons, will continue as consultant to the executive secretary. He will be especially concerned with the Society's long-range planning program. Raymond E. Hess will continue as associate executive secretary. As technical secretary and editor-in-chief, Mr. Hess is responsible for the technical activities and publications of the Society.

Mr. Marshall was born in Savannah, Ga., in 1911 and received his early education there. In 1932 he was graduated from Georgia Institute of Technology (then Georgia School of Technology) with a B.S. degree in aeronautical engineering.

From 1932 until 1951, except for five years' active duty with the U. S. Navy during World War II, Mr. Marshall was employed in the main office of the Metropolitan Life Insurance Co., first in various capacities in stationary engineering and later in posts of increasing responsibility in the Coordination Division.

In 1951, Mr. Marshall became executive secretary of the Engineering Manpower Commission, which had just been formed by Engineers Joint Council, and a year later became secretary of EJC as well.

Mr. Marshall joined the staff of ASME in 1954 to manage the society's 75th Anniversary Celebration and its public relations activities. In 1956 he was named head of Technological Service, leading to his appointment as assistant secretary and, later, senior assistant secretary.

During World War II, he served as gunnery officer of *USS Orizaba*, executive officer and commanding officer of *USS Saturn*, and commanding officer of *USS Lumen*. He also served as assistant engineer and material officer on the staff of Commander Service Force, U. S. Atlantic Fleet. He attained the rank of commander, and was recently retired from the U. S. Naval Reserve.

Mr. Marshall is a member of the American Society for Engineering Education, ASME, Human Factors Society, U. S. Naval Inst., Tau Beta Pi, Army and Navy Club, Georgia Tech Club of New York, Engineer's Club of New York, National Society of Professional Engineers, and Engineering Institute of Canada. He is a registered professional engineer in the state of New York.

Mr. Van Atta has been assistant secretary of ASTM since shortly after joining the staff in 1953. Prior to that, for a year, he was assistant managing director and manager of the Building Division of the Carolinas Branch, Associated General Contractors. From 1946 to 1952, he was assistant secretary of the American Concrete Inst. and later acting secretary-treasurer.

Mr. Van Atta is a native of Michigan and was graduated from Michigan State University in 1934 with the degree B.S. in C.E. with High Honor. Early experience included precise leveling with the U. S. Coast and Geodetic Survey, foundation exploration and construction with the Tennessee Valley Authority, hydraulic engineering with the Corps of Engineers, and structural steel design.

T. A. MARSHALL, JR.

During World War II, he served as a construction engineering officer with the U. S. Army Corps of Engineers in the States and in the Philippine Islands. He is a lieutenant colonel in the U. S. Army Reserve.

Mr. Van Atta is a Fellow of the American Society of Civil Engineers, a member of ASTM, American Concrete Inst., Tau Beta Pi, Phi Kappa Phi, and is a past director of the National Association of Exhibit Managers. He is a registered civil engineer in South Carolina.

Mr. Hess is well known in materials and standardization circles. He has been a member of the ASTM staff since 1920.

Standardization and the Purchaser*

By W. C. BRUNBERG

It is recognized that standardization is a subject that covers a very wide area—from the scientific field of outer space to the more common weights and measures. The area I should like to touch on is standardization in the manufacture of materials—the making of a product to fixed sizes and weights and other basic physical characteristics. Standardization of this nature is what enables the automobile industry, for example, to mass produce cars at the rate it does.

My primary concern is not in the manufacturing of a standardized product but in the purchase of material and equipment to maintain and operate a railroad. Purchasing people as well as manufacturers are interested and play a part in the setting of standards. Standardization can, and does, occur within a single concern to fill its own needs. Here is where nationwide industries, such as the railroads, create problems that make standardization almost impossible. Please note I said "almost," because it is a problem that is, of necessity, getting a lot of attention and some progress is being made.

Standards Have Benefited the Railroads

I believe that one of the first major problems railroads faced when the industry was in its infancy was trying to agree on a standard gage of railroad tracks. When this was finally resolved, an entire new conception of railroad transportation evolved, because a freight car could move from one line to another without the necessity of stopping at the end of each company's track and having the contents reloaded into the next line's equipment. You can well imagine the amount of time that would be lost and the potential damage to goods in handling if this were still true today.

This principle of standardization, however, has unfortunately never been carried to the degree on some of the major necessary items that railroad purchasing people would like to see. One of the reasons for this is the feeling that once suppliers have tied a product down to a standardized size, weight, shape, etc., there would perhaps be a tendency to higher profit through a reduction in quality. This feeling is being overcome slowly for the following reasons:

1. Standardization provides definite equal opportunities for competitive bidding on a product, and this broadens competition and helps ensure quality by giving the purchaser a basis for comparison.
2. It also often makes available more sources of supply.
3. It lowers unit costs by making mass-production methods possible. This, in turn, makes quantity discounts possible and increases the ability of a manufacturer to make long-range material planning programs.
4. It enables the purchaser to operate on smaller inventories at less cost, to buy in more economical quantities, and to improve the delivery time of material because of greater availability. The size of inventory carried is of great importance to every well-managed company. Unless the inventory is realistic, a large amount of working capital can be tied up unnecessarily.

The reasons just mentioned are purchasing reasons and are only a few, among many, but it all comes down to trying to achieve the basic purchasing objective of obtaining greater value for lower cost.

But Much Remains to Be Done

We in the railroad industry are currently concerned with a number of standardization projects.

For one example, let's take a look at rail sections (sizes of rail) in use by American railroads today. The Purchases and Stores Division of the Association of American Railroads has an active committee on simplification and standardization, and this group reported on rail sections this year, among many other things, and came up with some very interesting facts. The fact that one of the five major producers of railroad rail in this country declined to participate in the study leaves it incomplete, but perhaps the picture would have been even more involved had they participated.

They discovered that there are at least 43 rail sections made and available, ranging from 65 to 155-lb rail. Owing to the railroad industry's arbitrary use of so many different rail sections, the rail producers are required to make an average of ten roll changes per month. This amounted to an annual figure of 57,800 man-hr, or $157,000 for labor to change rolls. Frequent changing of rolls requires considerable handling costs, and production planning costs go up. It was further developed that about 77 per cent of all rail was produced to only five sections. This means that for 23 per cent of the rail produced storage facilities must be provided, insurance carried, and interest on investment in rolls provided for in much greater amounts than for the 77 per cent.

The costs mentioned here are included in the selling price of new rail. It is apparent that the use of such a large variety of rail sections by American railroads has a very important bearing on the production costs of rail. Therefore, it follows that the railroads can do much to reduce rail production costs through standardization.

It might be well to mention also that for one type of rail section, one steel company makes 400 different frogs, 143 different switches, and 88 different guard rails. When one considers other sections of rail and other companies making this type of material the total number of different rail fittings becomes staggering. Suffice it to say that here is an area begging for standardization.

In addition to rail, there is the equipment used to carry the goods being transported. Probably the most common freight car in use today is called a standard 50-ton general-purpose box car. This sounds good and people say "at last the railroads are getting a standard piece of equipment, one that all companies have and use." Upon investigation, however, the manufacturers of this type of car, reporting on the sides, doors, ends, and roofs of the cars made, had the following to offer: Car sides varied in length from 50 ft $1\frac{3}{16}$ in. to 50 ft $7\frac{5}{8}$ in., with seven variations somewhere in between. The height of car sides are made from 10 ft 1 in. to 10 ft $10\frac{5}{16}$ in., including 15 variations. In addition to the variations in size, there are many differences in construction such as:

1. Welded or riveted sides,
2. Special side plate sections,
3. Special sill reinforcements,
4. Side post variations, and
5. Various sizes, weights, and designs of steel sections used.

The car doors appear to be fairly standard, but here we find door openings with twelve different heights from 9 ft $2\frac{5}{16}$ in. to 9 ft $11\frac{7}{32}$ in. The doors themselves vary in width from 7 ft $9\frac{7}{16}$ in. to 9 ft $4\frac{5}{8}$ in. in 22 different measurements and in height from 9 ft 10 in. to 10 ft $4\frac{7}{8}$ in. with 25 variations.

* Presented at the Third Pacific Area National Meeting of ASTM, San Francisco, Calif., Oct. 11–16, 1959.

The car ends and roofs are, of course, guided by the length and height of the car, so there are again many variations.

Advantages by the carload can be pointed out here if car sides, door openings, and doors were made to a standard. One example I consider important is the repair of a car having its sides or doors damaged. Under present rules governing car repair interchange, a car so damaged must be returned to the owner's shops for repairs, or the owner must ship parts to the railroad making repairs. If these items were standardized, the car could be repaired anywhere it happened to be damaged, as is now done with such items as couplers and wheels.

One other thing that would improve with a standard box car is delivery time on these repair parts. All manufacturers of car sides, ends, roofs, doors, etc., could keep an inventory on hand with the knowledge that it could be used by any railroad in the country. This would assure the railroads a much faster delivery than if the inventory is restricted to only the companies that originally manufactured the product. Also, from a purchasing point of view, this would possibly eliminate the necessity for an individual company carrying any inventory on these large, costly items.

The two specific things I have mentioned are only examples of what a wide variety of differences exist in, first, an item for which there has been little attempt to standardize and, second, a so-called standardized item. What I have said about the standard box car has a tendency to make people in purchasing view any product called a standard, or standardized, with reservations until it is proved to be a real standard. In other words, it is evident that many items are standardized in name only and must be investigated thoroughly before being purchased for replacement or interchangeable parts.

There Are Pitfalls

To arrive at a standardized product is one of the most difficult tasks facing any group. There are many things that must be overcome, and the first of these is the individual's desire for his own preference and the belief that his particular specifications are the best. I have heard it said many times that when executives are asked about their feelings on standardization they immediately have the reaction that it is a good thing, but in following this up it is generally found that he will agree to standardization as long as others concerned will go along with his ideas.

Obviously, there are limits beyond which it is not feasible to push standardization. It is as wrong to expect standardization to provide a universal answer to material or purchasing problems as to expect other programs such as human relations, work measurement, forecasting, organization planning, and the like to provide all the answers for other management problems. By their very nature, the standards evolved cannot be either perfect or perfectly comprehensive, any more than they can be permanent.

W. C. BRUNBERG joined the Western Pacific Railroad in 1937, occupying various positions prior to World War II. In 1952 he took part in a research study of store operation from which modern store facilities were constructed and methods and procedures were streamlined. In 1953 Mr. Brunberg was appointed Manager of Materials and Stores, in 1956 he was promoted to Manager of Purchases and Stores, and in April, 1959, was appointed Director of Purchases and Stores. Mr. Brunberg now occupies the position of Assistant Vice-President—Administration, in the Marketing Division of Western Pacific.

To try to standardize too much or too finely would, perhaps, be nearly as serious a mistake as not to standardize at all. Opponents of standardization believe that where overstandardization exists, progress is retarded because manufacturers become so tied down with rigid specifications that research for a new or better product suffers. I feel, however, that it is not standards, as such, that straightjacket operations but rather the failure to arrive at adequate standards in the beginning. Similarly, it is not the standards that retard progress but the failure to revise them when the need arises.

Responsibility of the Purchaser

I believe that purchasing officers have a definite responsibility in this matter—they should encourage suppliers to continue their efforts to make a "better mousetrap"; and where standards do exist, purchasing people should indicate their willingness to manufacturers to institute action with their companies for progressive and constructive modifications of existing standards.

In the area of standards, there is one type I like to call purchasing standards. Broadly conceived, purchasing standards can cover everything a company buys, and for some companies they do. However, for most companies, explicit standards used in purchasing are primarily materials standards. These standards may be developed in the design of a product for its ultimate use or as performance standards defining acceptable materials for company use. In either event, they attempt to become the means of clear communication between the departments requisitioning materials and the department processing purchase orders. The significance of materials standards developed primarily from an engineering standpoint may be different from that of standards developed on other bases, since in one case technical considerations may be paramount and in the other case such economic factors as price, availability, and frequency of use must be considered. When materials standards used in purchasing are among the standards dealt with on any item, it can readily be seen that the reconciliation of different points of view becomes a very important and necessary function.

While my remarks have principally concerned railroad purchasing, the factors mentioned are generally true in all industry procurement. The National Association of Purchasing Agents, on both a national and local level, has long recognized the need for standardization and has been extremely active in this effort through their Value Analyses and Standardization Committee work.

Finally, I would like again to express, from a purchasing viewpoint, some of the advantages that I feel standardization offers:

First, is the reduced cost of a standardized product because of greater manufacturing competition.

Second, is the enhanced availability because of more sources of supply, which, in turn, reduces the length of delivery times.

Third, material costs are maintained or decreased as the result of making mass production techniques possible.

Fourth, a company can operate on a reduced inventory, with faster inventory turnover, and thus reduce losses through deterioration and obsolescence.

In closing, I believe one comment is appropriate—while there has been progress in the field of standardization, there appears to be one area in the overall effort that is somewhat deficient. I am referring to the actual creation of standards. There seems to be a pattern of one department in a company generating the specifications and standards. This can come from Engineering, Research, Production, etc. If a joint departmental effort were made to create standards rather than to have these take form in one department only, it would appear that more realistic specifications and standards could be created. By having all departments involved play an active part in this effort, by recognizing the importance of standardization, encouraging, suggesting, and placing into effect its principles, a better job can be achieved for our companies to reduce expenditures and, conversely, to increase profits.

ASTM Standards for Highway Materials*

By F. N. HVEEM

I SHOULD LIKE to present the viewpoint of a state agency on the usefulness of ASTM standards in the field of highway materials. In this particular field, there is an alternative source of nationwide specifications, namely, in the publications of the American Association of State Highway Officials. While AASHO specifications are modeled after those of ASTM and in many cases are identical, nevertheless, occasionally additional tests and modifications are introduced that are more agreeable to the highway engineer than may be the case with some of the ASTM requirements. Therefore, a state highway agency has considerable latitude of choice in the form of specifications that may be used, and so far as the department that I represent is concerned, we have the option of following ASTM, AASHO, or our own special requirements and are not seriously inconvenienced by any inadequacies in ASTM standards.

There are not many points that merit legitimate criticism, and therefore these comments should be interpreted as saying that in general we fully appreciate the value of the ASTM standards, and, in common with most other technical organizations in the United States, we fully realize the great value, dependability, and general suitability of ASTM methods.

Pull and Haul in Committees

We hold the view that the plan of organization of ASTM committees is excellent, providing as it does for representation on each committee of producers, consumers, and general interests, with the producers in the minority. In spite of the soundness of this theoretical setup of the committees, however, the actual operation at times is something less than ideal. Thus, there have been occasions when producing interests have been able to obstruct desirable changes in standards. This situation usually comes about simply as a result of being on the job. When the question of test requirements is all-important, manufacturers and producers usually see to it that they are well represented at committee meetings where the business is transacted. This is in no sense a reflection on the producers; rather it testifies to the importance that they attach to ASTM standards and committee activities. In contrast, many consumer representatives, especially those representing public agencies, often find it very difficult or impossible to secure approval for travel expense to attend ASTM committee meetings.

All ASTM specifications are the result of a joint effort on the part of producers and consumers. A typical and characteristic picture, however, places the user in the role of trying to write definite and relatively restrictive specifications in order to make sure that the agencies paying for the material will get what they want. It is also almost universally true that producer members of such a group will be seeking for greater tolerances, more latitude, and in general trying to broaden the specifications so that they often become ineffective or meaningless. It is also true that certain producers have sought to promote ASTM test methods that were more restrictive in certain respects than appear to be necessary simply because they were able to meet the restrictive specifications with ease and therefore in certain cases were able to gain an advantage over their competitors.

Obstructive Tactics

One good illustration of obstructive tactics has been in the consideration of establishing limitations on the alkali content of portland cement. The original working committee was composed of seven members, three of whom were producers. The consumers performed a vast amount of work and produced exhaustive data to prove that there was a need for restricting the alkali content of cements when reactive aggregates were involved. One of the producer members, quite properly, produced data to show that simply restricting the alkali content might not be a complete solution to the problem.

The other two producer representatives, however, did no work, entered into no discussion, but when the time came for a final decision within the subcommittee, they voted "No," and the three negative votes were sufficient to kill a recommendation that an optional limitation on alkalies be included in ASTM specifications for portland cement. As a result of this action, ASTM specifications still do not recognize the alkali constituent in portland cement as an important factor in its performance. While it now seems probable that the Society will ultimately approve specifications providing for limitation on alkalies, this important step has long been delayed, primarily because of producer opposition.

In most instances, the Society will not adopt specification requirements in the face of determined opposition by a vocal minority even though there is strong sentiment for adoption on the part of the great majority. A case in point is the move to relegate the tensile strength test for portland cement to a secondary position. The specifications now provide that unless otherwise stipulated by the purchaser, the requirements for tensile strength only shall apply. It has been the desire of the majority to provide that the compressive strength requirement shall apply unless otherwise specified. Convincing data have been presented to show that the compression test is a better indicator of the strength-producing properties of the cement in concrete both in compression and flexure. In this case, it appears that the commercial laboratories are the chief opponents of the move to indicate preference for compression tests. Their action presumably has stemmed from the fact that compression testing requires more costly equipment. To date, the specifications still state that tensile requirements will apply unless otherwise specified. In contrast, the AASHO specifications provide that the compressive requirements shall apply unless otherwise stipulated.

Needs for Specific Changes

There are a number of specific examples in which we feel that ASTM standards could be changed or improved to the advantage of most of those who pay for the materials. For example, there should be a more significant method for limiting the amount of clay-like particles in concrete aggregates than by simply stipulating the amount passing a No. 200 sieve. The present ASTM Method of Test for Measuring Mortar-Making Properties of Fine Aggregate (C 87)[1] tells very little about the strength-producing properties of

* Presented at the Third Pacific Area National Meeting of ASTM, San Francisco, Calif., Oct. 11–16, 1959.

[1] Method of Test for Measuring Mortar-Making Properties of Fine Aggregate (Tentative), 1958 Book of ASTM Standards, Part 4, p. 509.

sands in concrete. The ASTM Specifications for Ready-Mixed Concrete (C 94)[2] should be more specific with respect to means for recording the number of revolutions of a truck-mounted mixer. Freezing-and-thawing tests, C 290,[3] C 291,[4] C 292,[5] and C 310,[6] are believed to be unrealistically severe.

Manufacturer Favored

There is another criticism that can be made which is somewhat similar to the foregoing, namely, that in most specifications, if there is a choice of direction it will always lean in favor of the manufacturer. This point may be illustrated by the following quotation relating to structural steel:

"All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere with the operation of the works."[7]

It has been our experience that in the majority of manufacturing and fabricating plants it is impossible to comply literally with this wording and still do an efficient job of inspection. We think that a more realistic and equitable balance would exist if the last part of the paragraph were changed to read:

"... and shall be so conducted by cooperation between the manufacturer and the representative of the purchaser that interference with the operation of the works shall be held to the minimum compatible with good inspection."

Overlapping

Another field for criticism is the fact that there is often overlapping and lack of clear-cut objectives for some of the subcommittees. Admittedly, it is a difficult matter to prevent such overlapping, but it would seem that at times insufficient thought has been given to the scope of the committees and they have been set up without realization of the direction in which the work would inevitably lead. For example, in 1957, Subcommittees B-18 and B-19 of ASTM Committee D-4 on Road and Paving Material were simultaneously working on the design of an oven for the thin-film test for paving asphalts.

Slow Progress

There have been criticisms because of failures of committees to come up with workable specifications. For example, Mr. W. B. Warden has written:[8]

"Standing committees of ASTM ... have worked on this problem for years. Why then have these efforts not been more productive?"

Mr. Warden went on to say:

"Such committees are composed of men who have full-time jobs and responsibilities elsewhere. Meetings are held normally only once or possibly twice a year. Customary committee activities in any group *on a part-time voluntary basis* are just not conducive to rapid progress by reason of its physical make-up."

Test Methods Praiseworthy

I have dealt mainly with the content of ASTM specifications for materials. The other important activity of the Society is in the field of developing methods of test. As a testing agency, we are fully aware of the pitfalls that arise from ambiguous or incomplete statements of test conditions. In this respect, I can offer little but praise for the conscientious and time-consuming work of the committees.

It is, of course, much easier to criticize than it is to suggest how conditions may be improved or drawbacks eliminated. With respect to specifications for materials, it does appear that the Society should not lean any further than it now does in the direction of protecting or favoring the producer or manufacturing interests.

F. N. HVEEM joined the California Division of Highways in 1917, and since then he has held successive civil engineering positions in the highway field. He joined the Materials and Research Department in 1930, and became materials and research engineer in 1951. He is a member of the American Society of Civil Engineers and of ASTM. He is the author of several technical papers.

[2] Specifications for Ready-Mixed Concrete, 1958 Book of ASTM Standards, Part 4, p. 600.

[3] Method of Test for Resistance of Concrete Specimens to Rapid Freezing and Thawing in Water (Tentative), 1958 Book of ASTM Standards, Part 4, p. 684.

[4] Method of Test for Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water (Tentative), 1958 Book of ASTM Standards, Part 4, p. 688.

[5] Method of Test for Resistance of Concrete Specimens to Slow Freezing and Thawing in Water or Brine (Tentative), 1958 Book of ASTM Standards, Part 4, p. 692.

[6] Method of Test for Resistance of Concrete Specimens to Slow Freezing in Air and Thawing in Water (Tentative), 1958 Book of ASTM Standards, Part 4, p. 696.

[7] General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use (Tentative), 1958 Book of ASTM Standards, Part 1, p. 429.

[8] W. B. Warden, "Quality of Asphalt Cements as Reflected by Specifications," presented at a meeting of the Canadian Technical Asphalt Assn., November, 1958.

Papers Invited for Symposium on Electron Device Processing

COMMITTEE F-1 ON MATERIALS for Electron Tubes and Semiconductor Devices will sponsor a three-day Symposium on Materials and Electron Device Processing, April 10–12, 1961, at the Franklin Inst. in Philadelphia, Pa. The symposium will deal principally with the chemistry and physics of device processing and will bring up to date and expand the areas covered in the 1958 Symposium on Cleaning of Electronic Device Components and Materials, published by the Society as *STP 246*. It is expected that this symposium will deal extensively with a variety of materials and processing problems common to electron tubes and other solid-state devices.

Areas to be covered will include detection and removal of contaminants from device materials; examination and evaluation of materials and device processing facilities, such as chemical etchants and solvents; ambient conditions including furnace atmospheres and dust and lint control; and the chemistry and physics of device activation and reliability.

A number of papers have already been submitted for inclusion in the program. Additional papers are invited. Those desiring to submit a paper for consideration should submit the title and 200-word abstract to D. E. Koontz, Bell Telephone Laboratories, Inc., Murray Hill, N. J. Titles and abstracts should be in Dr. Koontz's hands not later than January 2, 1961. Manuscripts are desired by February 15, 1961.

New SAE Secretary

Many members of ASTM will be interested to know that the acknowledged dean of engineering society secretaries, John A. C. Warner, long-time secretary and general manager of the Society of Automotive Engineers, retired from those positions as of July 1, and became a consultant. He was succeeded by Joseph Gilbert, who had been his assistant for some time. The ASTM Staff down through the years has had many and pleasant and constructive contacts with both Messrs. Warner and Gilbert. SAE and ASTM are joint sponsors of a number of important activities in the field of standardization and research, and there is considerable cross representation on the respective technical committees.

Scott Urges Larger U. S. Effort in International Standardization

Cites Progress in Electrical Insulation Field

On the eve of his trip to New Delhi, India, as a member of the U. S. delegation to the IEC/TC 15 meetings, Arnold Scott told Frank Speight of the ASTM Staff why it is imperative for this country to step up its effort in international standardization work. Dr. Scott, a physicist with the National Bureau of Standards, is currently chairman of Committee D-9 on Electrical Insulating Materials. He has been chairman of ASA Sectional Committee C59 on Electrical Insulating Materials since 1949 and is the technical advisor on insulation to the U. S. National Committee for The International Electrotechnical Commission. He has represented the United States at many international meetings. Mr. Speight is reporting the conversation for the benefit of BULLETIN *readers.*

Q: Dr. Scott, in view of the many opportunities you have had to observe the growing industrial capacity of other countries in your various trips abroad, do you feel that this growth offers a challenge to us in the United States?

A: I am deeply concerned with the lack of interest in this country in international standards. We are too smug in our feeling that our technology and industry lead the world—that our way is best, that we do not need international standards. If we are to share in international markets—especially the markets opening up in underdeveloped countries—we must become more standards-minded. Countries that are just now developing their resources and industry will most likely pattern their standards after international standards, and we shall be handicapped in the foreign market if we don't participate fully. We should, therefore, take a more active part in developing international standards to make sure that our point of view is well presented.

Q: Besides the economic advantages, what are some other benefits of international standardization, as you see them?

A: Apart from the help in trade relations provided by uniform standards, great as this may be, we have also the stimulus provided by exchange of ideas and technical information at the international level. These international meetings help us to know each other better and decrease our distrust of one another. They contribute in a small way to the building of a permanent peace in the world.

Q: How does the work of the IEC relate to ISO and the UN?

A: The International Electrotechnical Commission, or IEC, was organized in 1906. Since then the many recommendations it has published have helped to coordinate and unify the standards of member countries. In 1947, the IEC became affiliated with The International Standards Organization (ISO) as its electrical division, while preserving its technical and financial autonomy. Through the ISO, the IEC has consultative status with the Economic and Social Council of the United Nations (UNESCO).

Seven working groups of IEC Technical Committee 15 on Insulating Materials held meetings during the general meetings of the IEC in Philadelphia in 1954. In the relatively short time since, there have been published IEC recommendations dealing with methods for volume and surface resistivities of insulation (IEC 93) and for tracking index under moist conditions (IEC 112). Another publication, "Encyclopedia of Electrical Insulating Materials" is being published in English, French, and German. Other monographs on individual materials are being prepared. This project was led by the Swiss members of IEC/TC15. Other documents that are well along toward approval deal with measuring electric strength of materials and dielectric constant and dissipation factor. Also in the works are publications on conditioning and thermal endurance of materials and on requirements for cells to be used in measuring resistivity.

The work of revising the temperature classifications of insulating materials is going on internationally. TC 15 has worked closely with TC 2C on Insulation Classification (of the Rotating Machinery Committee) in the development of Publication 85, "Recommendations for the Classification of Materials for Insulation for Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service." This publication and the others I mentioned are available in this country from the American Standards Assn.

Q: What other projects are under way?

A: These are indicated by the titles of the present nine working groups: (1) electric strength; (2) volume and surface resistance, insulation resistance, and conditioning of materials for test, (3) tracking and arc resistance, (4) voltage endurance including effects of corona, (5) assembly of an encyclopedia of electrical insulating materials; (6) dielectric constant and loss properties; (7) temperature characteristics of materials, (8) effects of nuclear and high energy radiation, and (9) mechanical properties of materials.

Q: In addition to the insulating materials committee, how many other committees are there in IEC?

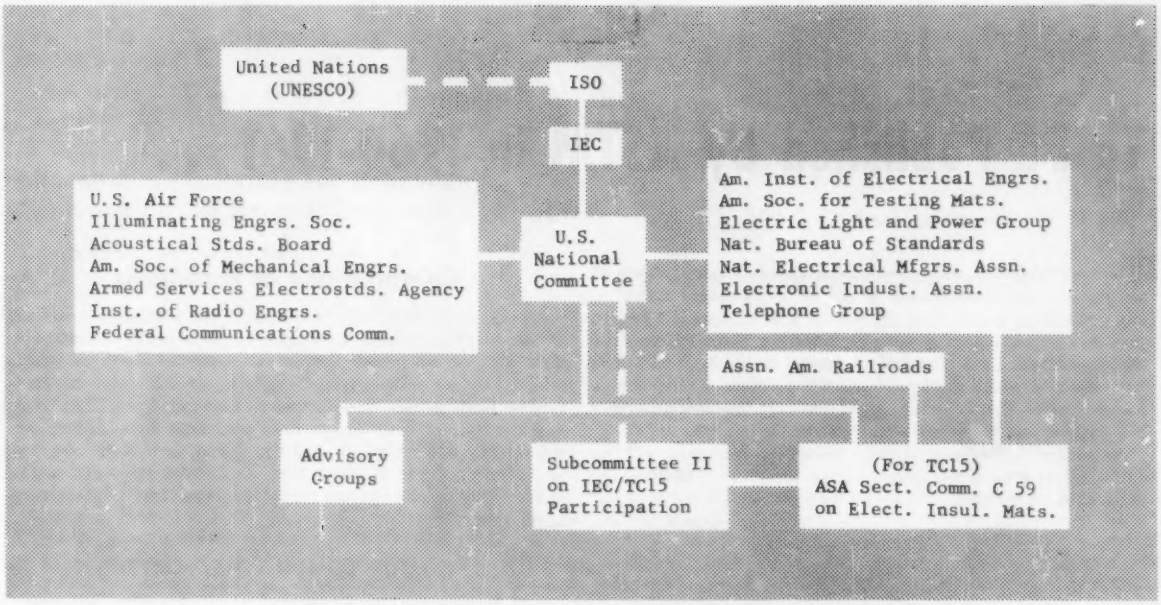


Fig. 1.—Organizations participating in IEC.

"I am deeply concerned with the lack of interest in this country in international standards."

A: There are now 43 technical committees, and subjects include nomenclature, turbines, traction equipment, power converters, lamps, batteries, electron tubes and semiconductor devices, and electric fans, among others.

Q: Let's go back to an earlier subject—the matter of increasing the level of participation in international activity. It is easy to see how adequate representation can be provided in those countries where all the standardization is under government auspices. But here in the United States we have many groups working on standards. How do they channel their efforts?

A: Perhaps we should have a brief rundown on how our U. S. participation in the IEC is effected. The chart (Fig. 1) shows how the various interests are mobilized to provide a united front for IEC participation.

The U. S. member of the IEC is the U. S. National Committee, which operates in conjunction with the American Standards Assn. The USNC looks to appropriate sectional committees organized under ASA rules to provide the working committees and delegations. It looks to its member organizations for policy guidance and in some cases financial support for representatives to attend meetings.

Q: Would a trade association, say, pay traveling expenses for delegates who might not be able to get support from their companies?

A: Yes, this is done, but this type of support is very limited. I believe that more general financial support should be made available. The most desirable delegate, for example, might be from a small company that is not in a position to pay the expenses to the meetings of IEC time after time, even though continuity of representation is highly desirable. Furthermore, most companies can justify these expenses only on the basis that the delegate can transact business for his company in the area where the meeting is being held. This has made it difficult to get delegates to the New Delhi meeting this fall, because few companies have business to transact there.

It should be evident that money spent for traveling expenses for delegates is well spent, and such support should be increased both by individual companies and by trade associations to improve our position in international standardization.

Q: While we are participating in international standards work, are there some areas where we are not well represented or not represented at all?

A: I should point out that international standardization in the electrical field is older and better established than in other industrial areas. The IEC has been operating for over 50 years, whereas the ISO has only been going for about 15 years. Even in the electrical field, however, there is need for increased U. S. participation. There are a number of IEC committees in which the U. S. does not participate. We should seek to have active participation in all the areas—especially those of greatest industrial significance.

"We are too smug in our feeling that our technology and industry lead the world—that our way is best, that we do not need international standards."

To Be Published by ASTM in 1960-1961...

The ASTM publications scheduled to appear within the next 12 months are the crystallization of the Society's recent activities, and possibly no summary of the Society's work is more effective than one on coming publications. From the Third Pacific Area National Meeting last October 17 special technical publications have resulted, which greatly increased our volume of publications for the year. The following pages preview the coming year's publications and review some that are already in print.

As future publications become available, members will be advised, and notices will appear in the BULLETIN. Most of the publications will bear special prices for members

Regular Publications

1960 Supplements to 1958 Book of Standards

The three-year cycle of the Book of Standards marks 1959 and 1960 as Supplement years. The 1960 Supplements to the 1958 Book of Standards will be issued in ten parts in heavy paper covers. These books will include the new and revised standards and tentatives adopted or accepted at the 63rd Annual Meeting or by the Administrative Committee on Standards. The ten parts, totaling some 2000 pages, are:

Part 1—Ferrous Metals (Specifications)
Part 2—Non-Ferrous Metals (Specifications), Electronic Materials
Part 3—Methods of Testing Metals (Except Chemical Analysis)
Part 4—Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils
Part 5—Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests
Part 6—Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather
Part 7—Petroleum Products, Lubricants, Tank Measurements, Engine Tests
Part 8—Paint, Naval Stores, Aromatic Hydrocarbons, Coal and Coke, Gaseous Fuels, Engine Antifreezes
Part 9—Plastics, Electrical Insulation, Rubber, Carbon Black
Part 10—Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes

Several of the parts are now on press. It is hoped that all parts will be available by the end of the year.

Methods for Chemical Analysis of Metals

A new edition of this book this year will contain all of the current ASTM methods for the chemical analysis of ferrous and non-ferrous metals and alloys, including methods for spectrochemical analysis. It is essentially a part of the Book of ASTM Standards. These methods are intended for general use in buying and selling materials according to specifications and are planned to provide such precision and accuracy that when used by competent analysts they will be found satisfactory for judging the adherence of materials to specifications.

Compilations of Standards

So many factors affect the release of the compilations that it is not possible at this time to give an accurate estimate of their size or the dates they will be available. The size is affected by committee recommendations which may be summitted through the Administrative Committee on Standards, and the date of issue is governed somewhat by editorial considerations and the relation of the special compilations to the appearance of the various parts of the Supplements to the Book of Standards. The tabulation given below is, therefore, approximate.

STANDARDS COMPILATION SCHEDULE

Sponsoring Committee	Title	Approximate Number of Pages	Approximate Appearance Date
A-1[a]	Steel Piping Materials	544	October
B-5	Copper and Copper Alloys	750	January
B-8	Electrodeposited Metallic Coatings	144	February
C-1	Cement	288	December
C-9, D-4	Mineral Aggregates, Concrete, and Nonbituminous Highway Materials	416	November
C-11	Gypsum Products, Plaster Aggregates, and Related Standards	152	November
D-2	Petroleum Products Vol. 1[b]	1056	October
	Vol. 2	758	December
D-4, D-8[b]	Bituminous Materials for Highway Construction, Waterproofing, and Roofing	488	October
D-12	Soaps and Other Detergents	282	January
D-13	Textile Materials	956	November
E-2	Methods for Emission Spectrochemical Analysis	632	November
	Student Pamphlet[b]	392	September

[a] Announced in September Bulletin.
[b] Available now.

Petroleum Products and Lubricants

Compilation of Standards, D-2

(Vol. 1 available now)

The rapid expansion of standardization work in the petroleum field has necessitated the publishing of the 1960 Compilation of ASTM Standards on Petroleum Products and Lubricants in two volumes. The first volume is now available.

Contents for the first volume include: measuring and sampling petroleum and petroleum products, crude petroleum, liquefied petroleum gases, butadiene, motor and aviation fuels, petroleum solvents and naphthas, diesel fuels, distillate and residual fuels, kerosine and illuminating oils, engine lubricating oils, industrial oils, cutting oils, turbine oils, lubricating greases, petrolatum and paraffin waxes, and graphite.

The volume contains many appendices, including 12 proposed methods published as information only. A few of the new standards included are: Analysis of Butane-Butene

Mixtures, Luminometer Numbers of Aviation Turbine Fuels, Functional Life of Ball-Bearing Greases, and Rust-Preventative Properties of Lubricating Greases.

ASTM Standards on Petroleum Products and Lubricants, Vol. 1, 1130 pages, hard cover, price $9.50, to members $7.60.

Bituminous Materials for Highway Construction, Waterproofing, and Roofing

Compilation of Standards, D-4, D-8

(Available now)

The 1960 edition of the Compilation of ASTM Standards on Bituminous Materials for Highway Construction, Waterproofing, and Roofing, containing over 100 specifications, methods of tests, and definitions, serves as a guide for the production and use of bituminous materials in both highway and building construction.

Over 40 standards are new, revised, or changed in status since the compilation was last issued in 1958. Among the newly added standards are: Specifications for Asphalt Paving Mixtures, Hot-Mixed, Hot-Laid; Specification for Woven Glass Fabrics Saturated with Bituminous Substances for Use in Waterproofing; Method of Test for Coating and Stripping Bitumen-Aggregate Mixtures; and Method of Test for Failure End Point in Accelerated and Outdoor Weathering of Bituminous Materials.

This volume is invaluable to highway engineers, state highway departments, and others concerned with the national highway program. Builders and others working with roofing and roofing materials will find this volume extremely useful.

ASTM Standards on Bituminous Materials for Highway Construction, Waterproofing and Roofing, 488 pages, hard cover, price $5.50, to members $4.50.

1960 Index to ASTM Standards

This Index is a ready reference for locating any ASTM standard appearing in any of the ten Parts of the Book of ASTM Standards and the Methods of Chemical Analysis of Metals. The Index is also of service in ascertaining whether the Society has issued a standard on a specific subject. Standards are listed by subject and also by numerical designation. As the number of published ASTM standards grows, this Index increases in value.

1960 Proceedings

This 1400-page volume records the technical accomplishments of the year, including reports, papers, and discussions offered to the Society during the year and accepted for the *Proceedings*. Although the Society's publications program has expanded greatly in recent years with an ever-increasing number of Special Technical Publications, the *Proceedings* remains the repository of factual information and a record of the Society's work. An important adjunct is a Subject and Author Index to all papers published in any form by the Society in 1960.

Year Book

The Year Book contains a list of the complete membership, and official company-member representatives (name, title, address, company). This being an even-numbered year, the complete lists of subcommittee personnel will be published. The 1959 edition contained a list of the subcommittees and their officers but not the complete personnel. Reference will need to be made to the 1959 edition for the geographical listing of membership, which is published in the odd-numbered years but omitted in the even-numbered years. The Year Book also contains other useful information about the Society. It is furnished to members without charge, on request, and may be purchased by committee members.

1960 Gillett Lecture*

Nuclear Fuel Element Development

By R. C. Dalzell

(Available now)

The Ninth Gillett Memorial Lecture, "Nuclear Fuel Element Development," was presented by R. C. Dalzell, assistant to the director of the Division of Reactor Development, United States Atomic Energy Commission. This lecture, jointly sponsored by ASTM and the Battelle Memorial Inst., commemorates Horace W. Gillett, the first director of Battelle and one of this country's leading metallurgists.

Probably one of the most difficult problems facing the designers of nuclear reactors is that of standardization of fuel elements. In this lecture, Mr. Dalzell outlines the scientific problems and the engineering and economic considerations that are important in this developing industry. Research and development methods and observations are also discussed.

Single copies of the lecture, printed as a separate pamphlet, are now available to members on request. Additional copies to members, 80 cents. List price $1.00.

1960 Marburg Lecture*

Solar Energy

By Farrington Daniels

(Available now)

The Edgar Marburg Lecture was established as a memorial to the first secretary of the Society, to emphasize the importance of adding to our knowledge of properties and tests of engineering materials. At the 1960 Annual Meeting, the 34th Edgar Marburg Lecture, entitled "Solar Energy", was presented by Farrington Daniels, Professor Emeritus of the University of Wisconsin.

The lecture discusses the abundance and limitations of solar energy and reviews solar energy research, emphasizing particularly the new materials that are necessary in the successful application of solar energy. The research review includes the subjects of heating and cooling, distillation of salt water, solar engines, photoelectricity, thermoelectricity and photochemistry.

Single copies of the lecture, printed as a separate pamphlet, are now available to members on request. Additional copies to members, 80 cents. List price, $1.00.

Special Publications

Publications Resulting from Third Pacific Area National Meeting, October 11-16, 1959

Symposium on Hydraulic Fluids (STP 267)—sponsored by Committee D-2 on Petroleum Products. Significant advances in hydraulic fluid technology are described in this STP.

* Presented at the 1960 Annual Meeting in Atlantic City, N. J., June 26–July 1.

To Be Published by ASTM . . .

Available now. 108 pages, price $3.75, to members $3 (see April BULLETIN for description).

Papers on Soils—1959 Meetings (STP 254)—sponsored by Committee D-18 on Soils for Engineering Purposes. This volume includes all of the soils papers presented at the 1959 Annual Meeting and the Third Pacific Area National Meeting. Three symposia are included, namely, Time Rate of Loading in Soil Testing, Atterberg Limits, and Soils for Engineering Purposes, as well as general papers on soils.

Available now. 381 pages, price $9, to members $7.20 (see May BULLETIN for description).

Symposium on Effect of Water-Reducing Admixtures and Set-Retarding Admixtures on Properties of Concrete (STP 266)—sponsored jointly by Committees C-1 on Cement and C-9 on Concrete. The future of better concrete lies in an increased understanding of concreting materials and the best manner of combining them to produce the maximum in strength and durability, and it was for this purpose the symposium was organized.

Available now. 252 pages, price $7.50, to members $6 (see May BULLETIN for description).

Symposium on Spectroscopy (STP 269)—sponsored jointly by Committees E-2 on Emission Spectroscopy and E-13 on Absorption Spectroscopy. The theme of the program was unsolved problems, and the symposium includes emission, X-ray, flame photometry, ultraviolet absorption, magnetic resonance, and infrared spectroscopy.

Available now. 251 pages, price $7, to members $5.60 (see May BULLETIN for description).

Symposium on Durability and Weathering of Structural Sandwich Construction (STP 270)—sponsored by Committee C-19 on Structural Sandwich Constructions. This symposium was planned to cover service experience and durability tests for two major users of sandwich materials, the aircraft and building industries.

Available now. 77 pages, price $3, to members $2.40 (see May BULLETIN for description).

Symposium on Newer Metals (STP 272)—sponsored by Committee B-2 on Non-Ferrous Metals and Alloys. The three topics covered in this volume are properties of refractory metals, nuclear and light metals, and processing of newer metals.

Available now. 224 pages, price $7.25, to members $5.80 (see May BULLETIN for description).

Symposium on Fatigue of Aircraft Structures (STP 274)—sponsored by Committee E-9 on Fatigue. The purpose of this symposium was to discuss recent advances and the current state of development of solutions to various phases of the aircraft fatigue problem.

Available now. 144 pages, price $4, to members $3.20 (see July BULLETIN for description).

Symposium on Air Pollution Control (STP 281)—sponsored by Committee D-22 on Methods of Atmospheric Sampling and Analysis as part of its continuing program toward solution of air pollution problems by exchange of information and establishment of standards for analysis of the atmosphere.

Available now. 50 pages, price $1.50, to members $1.20 (see July BULLETIN for description).

Materials in Nuclear Applications (STP 276)—comprises Symposium on Ceramics in Nuclear Energy, sponsored by Committee C-21 on Ceramic Whitewares and Related Products; Symposium on Radiation Effects and Dosimetry, sponsored by Committee E-10 on Radioisotopes and Radiation Effects; and Symposium on Post-Irradiation Effects in Polymers, sponsored jointly by Committees D-9 on Electrical Insulating Materials and D-20 on Plastics. Also several papers on industrial water for reactor use, sponsored by Committee D-19 on Industrial Water, are included in this volume.

Available now. 350 pages, price $8.25, to members $6.60 (see September BULLETIN for description).

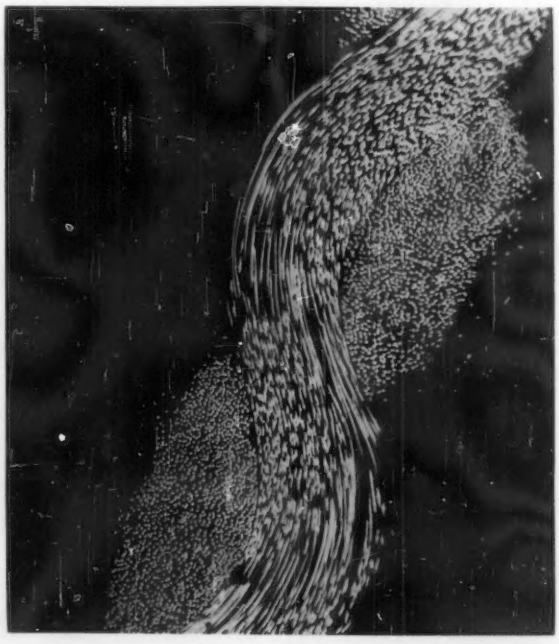
Symposium on Nondestructive Testing in the Missile Industry (STP 278)—sponsored by Committee E-7 on Nondestructive Testing. The purpose of this symposium was to establish a background of unclassified literature on a limited number of specific applications of nondestructive testing and to stimulate thinking by outlining many of the present nondestructive testing problems in the missile industry.

Available now. 77 pages, price $2.00, to members $1.60 (see September BULLETIN for description).

Symposium on Bituminous Waterproofing and Roofing Materials (STP 280)—sponsored by Committee D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses. Of the eight papers contained in this publication, five are of a general nature and cover aspects of manufacture, inspection, applications, and service requirements of certain principal categories of materials, and three are of specialized experimental or theoretical interest.

Available now. 87 pages, price $2.50, to members $2.00 (see September BULLETIN for description).

Symposium on Treated Wood for Marine Use (STP 275)—sponsored by Committee D-7 on Wood. Marine borers have long been recognized as presenting a major problem in harbor development and maintenance, and it is the purpose of this publication to present current information on the problem.



GRAPHITE CLOTH—SOFT FILAMENTS

Graphite cloth containing soft filaments (approximately 5μ) was styrene impregnated, polymerized, and ground flat on cloth edge, then lapped on microcloth with alumina without smearing or rearranging the soft filaments. Magnification 50X, enlarged to 150X, reduced for publication. Twelfth ASTM Photographic Exhibit. G. L. Peters, National Carbon Co.

Available now. 75 pages, price $2.50, to members $2.00 (see article on page 18).

Symposium on Road and Paving Materials (STP 277)—sponsored by Committee D-4 on Road and Paving Materials. During recent years, much experimental work has been done in the field of asphaltic paving mixtures, particularly with respect to relating the properties of asphalt and aggregates to performance on the road. The purpose of this volume is to publish some of the activities along these lines carried out by the West Coast groups.

Available now. 132 pages, price $3.50, to members $2.80 (see article on page 18).

Symposium on Applied Radiation and Radioisotope Test Methods (STP 268)—sponsored by Committee E-10 on Radioisotopes and Radiation Effects. The purpose of this symposium was to develop some proposed ASTM methods of analysis and testing involving the use of radioisotopes as analytical tools.

Available now. Price and size to be announced. (see article on page 18).

Papers on Building Construction (STP 282)—comprises papers from the Symposium on Methods for Testing Building Construction, sponsored by Committee E-6 on Methods of Testing Building Construction, and the Symposium on Wood in Building Constructions, sponsored by Committee D-7 on Wood. The necessity for quality control in structural glued laminated timber, the advantages of diaphragms and full-scale testing of these assemblies, the importance of satisfactory end joints in laminated wood beams, screw-holding properties of various species of wood, wood-pole-type buildings, and termite control in California are presented in this publication.

Available in December.

Symposium on Technical Development in the Handling and Utilization of Water and Industrial Waste Water (STP 273)—sponsored by Committee D-19 on Industrial Water. The purpose of this STP is to show the variety of the problems that we face in providing the water supply for our growing population and expanding industry. Progress in nuclear chemistry requires adequate means of treatment and disposal of radioactive waste as well as adequate methods of analysis. The effect of industrial wastes on water for irrigation use and conversion of saline water are also discussed.

Available in December.

Symposium on Adhesives (STP 271)—sponsored by Committee D-14 on Adhesives. Twenty years ago, there was no commercial production of metal-to-metal adhesive bonded structures. Today, building spandrels, aircraft fuselages and truck trailers are among the growing list of items being glued together. The subjects covered in this volume include the experimental work in Germany on metal-to-metal adhesives, high-temperature resistance of five ceramic adhesives, elevated-temperature-resistant metal-to-metal adhesives derived from organic-inorganic polymer systems, and bonded metal-to-metal shear testing.

Available in December.

Reinforced Plastics for High-Speed Flight Vehicles (STP 279)—sponsored by Committee D-20 on Plastics. The demands for improved test methods in the field of reinforced plastics are being felt in a number of ways, and it is hoped this publication will contribute to the progress in this field. This volume includes papers from the Symposium on Reinforced Plastics and the Symposium on Thermal Ablation.

Available in December.

Other Special Publications

Symposium on Acoustical Fatigue (STP 284)*

Sponsored by Committee E-9 on Fatigue.

In the past few years a new source of air-borne vibration excitation has become important. The advent of supersonic flight and the development of high-thrust jet propulsion systems have greatly increased the level of random noise generated in aerospace vehicles. This acoustical energy is now large enough in many situations to excite fatigue-producing vibrations—a phenomenon now identified as acoustical fatigue or sonic fatigue. In the future, the acoustical environment that structures encounter are likely to become more severe. Thus, unless structures are designed specifically to resist acoustical fatigue, serious failure problems may result.

The five papers discuss the various properties of materials important in acoustical fatigue, the effect of these properties on acoustical fatigue life, and simulated environmental testing procedures for appraising acoustical fatigue properties.

Symposium on Spectroscopic Excitation (STP 259)*

Sponsored by Committee E-2 on Emission Spectroscopy.

(Available now)

This symposium considered some of the major effects on excitation caused by the sample itself—the so-called matrix effects—and by the environment in which excitation occurs—the gaseous atmosphere. These effects encompass a wide variety of phenomena, and it would not be practicable to attempt to treat all of them. However, the intention is to bring out some major causes and effects and to examine ways in which deleterious effects may be minimized or corrected in order to improve accuracy of analysis. One additional purpose of this volume is to bring out the more important problems in excitation so that attention may be directed toward their solution. To accomplish this purpose, searching discussions were considered important, and several authorities have prepared discussions which are included at the end of each of the three papers. The contents are:

The Matrix Effect in Excitation—J. K. Hurwitz
Effects of Gaseous Atmospheres on Excitation—George Andermann and J. W. Kemp
Some Properties of New or Modified Excitation Sources—Marvin Margoshes

STP 259, 68 pages, hard cover, price $2.50, to members $2.00

Symposium on Nuclear Methods For Measuring Soil Density and Moisture (STP 293)*

Sponsored by Committee D-18 on Soils for Engineering Purposes.

Soil and foundation engineers have for many years eagerly awaited development of a technique for accurate and rapid determination of the moisture content and density of compacted fills. Difficulties in obtaining measurements by conventional methods in certain types of soils sometimes impair the accuracy of such measurements. Quite recently, at the instigation of several organizations including Cornell University, The Civil Aeronautics Administration, and the U. S. Army Corps of Engineers, instruments have been developed using nuclear methods.

This STP details the development of these methods of test and the problems incurred. The six papers cover design and application of the Nuclear-Chicago d/m gage, design and

calibration of a neutron moisture meter, application of nuclear soil meters to compaction control for airfield pavement construction, experiences with nuclear moisture and density surface probes on the O'Hare Field project, comparison of nuclear and sand-cone methods of density and moisture determination, and evaluation of nuclear moisture-density testing equipment.

Symposium on Shear and Torsion Testing (STP 289)*

Sponsored by Committee E-1 on Methods of Testing.

It is expected that the eleven papers presented at this symposium will be helpful to the sponsoring committee in establishing tentative recommended shear and torsion test practices and will also provide a useful reference on the many aspects of shear and torsion testing.

The objectives of this symposium were (1) to obtain detailed descriptions of new or existing shear and torsion test methods as used on a wide variety of materials, (2) to determine the test variables in these test methods and to evaluate the effects of these variables on test results, (3) to compare test results using different test techniques or conditions, and (4) to describe the advantages and disadvantage of the various test techniques.

The following subjects are covered in the STP: maximum shear strain measurement and true yield point determination by the use of the photoelastic coating technique, stress distribution in single-shear sheet specimens, the design and development of a tensile-loaded shear specimen, an investigation into the load transfer and shear failure of spot welds, bonded metal-to-metal shear testing, lap-joint shear test for metal-to-metal bonds, preparation of metal surfaces for adhesive bonding, shear and torsion tests used at U. S. Forest Products Laboratory, a technique for torsion testing of refractory materials at temperatures up to 2800 C, and a photoelastic evaluation of panel shear test for plywood.

Symposium on Methods of Metallographic Specimen Preparation (STP 285)*

Sponsored by Committee E-4 on Metallography.

Metallography is one of the most important tools of the metallurgist in the continuous search for new and better metals, ceramics, and cermets for nuclear and missile applications. In recent years the metallographer has been called upon to examine many new and hitherto commercially unused metals and alloys in increasing quantities. Not only must he prepare his specimens more rapidly, but because of the wider use made of his field he must have better surface preparation than ever before. In fact, there has never been a real advance in metallography without a previous improvement in the prepared surface. Several of the new methods now in use are described in this volume, including those used for rapid polishing of materials and for the preparation of extremely fine surfaces, as well as remote-control methods.

The eight papers describe and evaluate several new techniques including vibratory polishing, chemical polishing, attack polishing, and cathodic vacuum etching. Several papers point out the usefulness of the presently available diamond abrasive in previous problem areas. The remote metallography of irradiated specimens is also covered.

Properties of Crystalline Solids (STP 283)*

Sponsored by Division of Materials Sciences.

Recent progress in materials sciences and the nature and origin of strength of materials are thoroughly explored in nine papers presented in the first two symposia sponsored by the new Division of Materials Sciences. Solid-state theory, properties of semiconductors, ductile ceramics, dislocations, and the mechanisms of creep and fracture are among the topics discussed. Recent advances in solid-state theory and application and the relation of structure to properties of materials is treated in the first four papers, which comprise the Symposium on Recent Progress in Materials Sciences. These papers describe and interpret what is now known of why materials behave as they do. Papers in the Symposium on Nature and Origin of Strength of Materials approach the strength property from different viewpoints to consider all major factors contributing to the strength of solid materials. Particular attention is given to the properties of crystalline solids. The papers in this group cover dislocations, fatigue, creep and fracture, and size and shape effects.

Also included in this volume is the talk by W. O. Baker of Bell Telephone Laboratories on "The National Role of Materials Research and Development," which was presented at the Material Sciences Luncheon.*

Symposium on Quality of Observations (STP 288)*

Sponsored Jointly by Administrative Committee on Research and Committee E-11 on Quality Control of Materials.

The purpose of this symposium was to discuss some fundamental problems in the interpretation of measurements. The quality of a test result is often implied by statements about the precision and accuracy, important statistical features of any measurement process. The four papers in this session attempt to clarify the meanings of these terms and to survey methods that can be used to determine precision and accuracy. The first paper covers the meaning of precision and accuracy. The second paper deals with how to evaluate precision, and the third paper, how to evaluate accuracy. The final paper shows how new techniques of analysis of residuals, multiple comparisons, and components of variance can supplement analysis of variance in answering many questions about processes and planned experiments not possible to answer by analysis of variance alone. The STP provides a better concept of the importance and meaning of the terms "precision" and "accuracy."

Papers on Road and Paving Materials—1960 (STP 294)*

Sponsored by Committee D-4 on Road and Paving Materials.

The cationic asphalt emulsion, one of the new developments in bituminous materials, is discussed in terms of laboratory tests and specifications that are needed for this material in one of the six papers comprising this publication. Another paper reviews emulsified asphalt tests. The subjects of stress-deformation characteristics of sand-bituminous mixtures, the effect of compaction temperature on the properties of bituminous concrete, a method for measuring air permeabilities of asphaltic concrete pavements, and the influence of asphalt composition on its rheology are covered in the four other papers.

Symposium on Low-Temperature Properties of High-Strength Aircraft and Missile Materials (STP 287)*

Sponsored by ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

Owing to the increasing use of cryogenic propellants such as liquid oxygen and liquid hydrogen in missiles and space

vehicles, the properties of high-strength structural materials at extremely low temperatures are becoming of prime importance. Until relatively recently, liquefied gases were produced primarily for commercial applications, and these low-temperature liquids could be adequately held and carried in tanks and piping made from low-strength materials. However, with the recent advent of nuclear weapons, of high-speed rocket-propelled aircraft, and finally, of large cryogenic-fueled missiles, it has become necessary to use materials having the highest possible strength-to-weight ratios in order to meet design and performance requirements.

The 14 papers in this volume consider the mechanical properties of promising high-strength structural alloys at temperatures ranging down to −423 F. In order to obtain optimum strength-to-weight ratios, most of the alloys reported were either heat-treated or cold worked to their highest strength levels commensurate with adequate toughness. Since this symposium was aimed primarily at missile and space vehicle applications, attention is focused on sheet alloys. Also, since weldability is of major importance in the fabrication of these vehicles, data pertaining to the low-temperature properties of welded joints in these alloys are reported. Finally, since toughness is of increasing importance where high-strength alloys are used at high stress levels and low temperature, data measuring resistance to brittle fracture are reported wherever possible.

Symposium on Radiation Effects and Radiation Dosimetry (STP 286)*

Sponsored by Committee E-10 on Radioisotopes and Radiation Effects.

The application of nuclear energy to problems in materials and materials testing, in addition to creating a few new problems, is adding some unusual aspects to many familiar problems that are requiring the attention of increasing numbers of the Society's committees. Two of the problem areas, radiation effects and radiation dosimetry, are the subject of this volume. Radiation effects refers broadly to the change in properties of materials due to exposure to nuclear radiation. It is perhaps the most dramatic of the problem areas in that it involves the influence of an additional environment on materials behavior. Radiation dosimetry, the measurement of the environment of nuclear particles, is one of the most difficult problems in nuclear technology. Direct counting of the particles is usually impractical, and measurement must be made by determining the effects of interaction of the particles in reference materials.

Subjects covered in the eleven papers are: determinant sample parameters in the radiation-effects testing of high polymers, irradiation testing of Enrico Fermi prototype fuel pins in the CP-5 reactor, the effect of neutron irradiation on the Charpy-V- and drop-weight-test transition temperatures of various steels and weld metals, reactor spectra considerations in radiation-effects predictions, radiochemistry and mass-spectrometry techniques for fuel-depletion studies, effect of sample parameters on energy absorption from a neutron beam, high-intensity gamma-ray dosimetry, a solid-state Bragg-Gray cavity chamber, measurements of the energy absorbed from the pile neutrons, neutron dosimetry for materials irradiation studies, and neutron spectrum determinations at low flux levels.

Index to the Literature on X-Ray Spectrographic Analysis, Part I, 1913-1957 (STP 292)

Sponsored by Committee E-2 on Emission Spectroscopy.

This is the first of a series of bibliographical surveys of the literature of X-ray spectrographic analysis. It covers the years 1913 through 1957, although it is admittedly not an exhaustive compilation. It contains an author index as well as abstracts and a subject index. The abstracts are largely quoted from *Chemical Abstracts*, but occasionally they are revised or specially prepared.

MINUS 70 F

Twelfth ASTM Photographic Exhibit. Daniel R. Condon, United States Testing Co., Inc.

1959 Supplement to the Bibliography and Abstracts on Electrical Contacts (STP 56-N)

Sponsored by Committee B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts.

(Available now)

This is the seventh supplement to the 1952 edition. The publication of this supplement makes it possible for everyone concerned with electrical contacts to keep up to date with the latest information. There are several new additions to the bibliography this year which deserve special mention. Through the cooperation of International Business Machines Corp., 131 papers on the subject of friction, lubrication, and wear, which had not been previously listed, are included in this supplement. The lists of titles and authors of papers that were given at the Symposium on Electromagnetic Relays, held at the Oklahoma State University in cooperation with the National Association of Relay Manufacturers, are included. The same is true of the Engineering Seminars on Electrical Contacts conducted by The Pennsylvania State University. The subject index lists the following headings: Books Covering the Subject of Electric Contacts; Electric Contacts—General; Contact Materials—Fabricated; Contact Materials—Powdered Metals; Circuit Breaker Design; Circuit Breaker Testing; Contactor or Relay Design; Stationary or Fixed Contacts; Sliding Contacts—Slip Rings; Sliding Contacts—Commutation; Contact Resistance; Electric Arc Theory as Applied to Contacts; Electric Arc Theory; Glow Discharge Theory; Spark Discharge Theory; Contact Wear; Circuit and Circuit Parameters as Applied to Contact Operation; and Friction and Lubrication. *STP 56-N*, 63 pages; Price $3.50, to members $2.80.

To Be Published by ASTM . . .

The Twenty-Year Atmospheric Corrosion Report on Metallic-Coated and Uncoated Wire and Wire Products (STP 290)

In 1936, over 10,000 specimens of fabricated and unfabricated wire and wire fence were exposed to the natural atmospheres of 11 exposure sites from Connecticut to California. Copper-bearing and stainless steels were included, as were copper, lead, and zinc coatings on mild and copper-bearing steels. The specimens have been visually observed and physically tested for change in tensile strength and loss of coating at regular intervals over the entire exposure period. Although the exposures are still continuing, it was decided that a thorough study of the findings at the 20-yr point should be made.

This report reviews all of the original data and includes the original photomicrographs of the specimens. The 20-yr data are given, and some 88 charts illustrate the changes in area of rust, breaking strength, and loss of coating for specimens of each type at each location over the 20-yr period.

Symposium on Applied Radiation and Radioisotope Test Methods (STP 268)

Sponsored by Committee E-10 on Radioisotopes and Radiation Effects.

(Available now)

In 1948 the Society recognized the unique potentialities of radioisotopes in testing procedures and formed Committee E-10 on Radioisotopes and Radiation Effects. For the past several years this committee has served primarily as an advisory group to other ASTM committees concerned with specific industrial products.

This symposium represents the first concentrated effort of Committee E-10 to develop some proposed ASTM methods of analysis and testing involving the use of radioisotopes as analytical tools. Publication of this STP is also intended to stimulate activity in other ASTM committees by suggesting ways in which methods involving radioactivity might be applied to other current test methods and to research problems.

The authors were informed that the papers should cover reasonably well-developed radioisotope test methods, aimed toward fulfilling the needs of specific industrial testing problems. The benefit of the radioisotope method, as compared with existing competitive methods, is highlighted so as to stimulate interest and lead to ultimate adoption of the technique as an accepted routine test procedure. The contents of this publication are:

Introduction—O. M. Bizzell
Radioactive Ring Wear Testing in Railroad Diesel Locomotives—C. F. Jursch, P. L. Pinotti, and D. R. Jones
Grain Boundry Segregation Studies by Activation—Warner W. Schultz
Removal of Radiotagged Fatty Soil from a Glass Surface—Jay C. Harris and R. M. Anderson
Calcium-45-Tagged Clay as Detergency Test Soil—J. W. Hensley and C. G. Inks
Measurement of Moisture and Density in Soils by the Nuclear Method—John Kuranz
Nuclear Method for Analysis of Sulfur in Hydrocarbons—George G. Manov and L. J. Beaufait
A Radiometric Method for the Determination of Magnesium Oxide in Portland Cement—J. E. Howes, Jr., C. T. Brown, D. N. Sunderman, M. Pobereskin, and P. Schall
Tracer Methods for Rapid Determination of the Uniformity of Mixing—Robert M. Main
Tracer Techniques for Thickness of Very Thin Vacuum-Evaporated Metal Films—Luther E. Preuss
Permeability Tests for Organic Sheet Materials—Meyer Pobereskin
Radioisotope Methods of Testing Uniformity of Coated Fabrics—George B. Foster and Henry R. Cope
Summary

STP 268, price and size to be announced.

Symposium on Treated Wood for Marine Use (STP 275)

Sponsored by Committee D-7 on Wood.

(Available now)

A major problem in harbor maintenance is to keep marine borers from seriously shortening the life of wood piling. These voracious wood-boring organisms attack and destroy millions of dollars worth of wood piling annually. The seriousness of the problem varies in different parts of the world and in different harbors, depending on the salinity of the water.

Treatment with creosote and other coal-tar solutions has long been considered the most effective means of discouraging marine borers, but this type of treatment has not been fully effective.

Committee D-7 on Wood has sponsored two symposia on the subject of wood and treatments of wood for marine use. Papers from the second of these, held during the Third Pacific Area National Meeting in San Francisco in October, 1959, appear in this volume.

A method for rapid screening of potential preservatives using small-size wood panels is given in one paper. Another reports studies of the toxicity of chemical agents to marine borers. Creosoted timbers from an old wharf provided a source of test animals for the toxicity tests.

Subjects of other papers include: column chromatography, a useful tool in separating saturated hydrocarbons from creosote; the inspection and evaluation of wood piles in sea water using a diver in full gear; various means of prolonging the life of wood piles, such as jacketing creosoted piles with several different materials including concrete and plastics; assay borings for determination of retention of preservative; and the results of the first biennial inspection covering installation of specimens of pressure-treated Douglas fir and southern pine at three sites on both the Pacific Coast and the Atlantic Coast.

Contents of the volume are:

Introduction—L. J. Markwardt
Use of Small Panels in Screening Potential Wood Preservatives—Thorndyke Roe., Jr., and Harry Hochman
Standard Toxicity Evaluation of Chemicals Poisonous to the Marine Borer—Harold Vind and Harry Hochman
Column Chromatography in the Analysis of Creosote—Richard W. Drisko and Harry Hochman
Evaluation of Wood Piles in Sea Water by Standard Rating System—E. V. Dockweiler and H. E. Stover
Extending Service Life of Wood Piles in Sea Water—C. M. Wakeman and L. L. Whiteneck
Determining Preservative Retention in Piling by Assay of Borings—R. H. Baechler
Marine Exposure Tests of Pressure-Treated Douglas Fir and Southern Pine—R. D. Graham and D. J. Miller

STP 275, 69 pages, hard cover, price $2.50, to members $2.

Symposium on Road and Paving Materials STP 277

Sponsored by Committee D-4 on Road and Paving Materials.

(Available now)

The behavior of asphalt paving mixtures in highways has been the object of much research and experimental work in recent years. One of the most notable and extensive projects has been the Zaca-Wigmore Experimental Test Road, sponsored by the California State Department of Public Works, Division of Highways. The primary purpose of this project was to observe the performance of asphalts from various

sources and manufacturers, complying with a new asphalt specification developed by the Division of Highways.

Three papers, two by representatives of the Division of Highways and the third by a representative of the Shell Development Co., present a wealth of information and test data on the results to date from the test road. The progress report prepared by the Division of Highways is included in this publication. Examination of the asphalts in the Zaca-Wigmore project by means of the microfilm durability test, described in the third paper, gave ratings of relative durability to be expected of asphalts when all are used under the same conditions.

The second part of the publication consists of four papers presented in a general papers session. A paper on influence of chemical composition of asphalts on performance points out that with relatively simple procedures and apparatus it is possible to obtain fundamental information on the chemistry of asphalts, long a very difficult task, and to correlate asphalt performance with composition.

Other papers discuss: the effect of variation in type, amount, and temperature of asphalt on the behavior of dense-graded paving mixtures in repeated flexure; a simple abrasion test wherein the saturated aggregate is abraded by rock-to-rock contact, which has proved more useful than the conventional quality tests to detect potential degradation; and a series of tests to produce plastic fines using the Los Angeles and the Deval abrasion test machines, introducing variations in time of rotation and checking moisture characteristics of the fine material.

The contents include:

Introduction—Bernard A. Vallerga

Symposium on the Zaca-Wigmore Experimental Test Road

Progress Report on the Zaca-Wigmore Experimental Asphalt Test Project—F. N. Hveem, E. Zube, and J. Skog

Results of Cooperative Test Series on Asphalts from the Zaca-Wigmore Experimental Project—J. Skog.

Correlation of the Microfilm Durability Test with Field Hardening Observed in the Zaca-Wigmore Experimental Project—W. C. Simpson, R. L. Griffin, and T. K. Miles

General Session

Influence of Chemical Composition on Asphalts on Performance, Particularly Durability—Fritz S. Rostler and Richard M. White

Effect of Temperature on the Flexibility Characteristics of Asphalt Paving Mixtures—Carl L. Monismith

Degradation of Mineral Aggregates—Carl E. Minor

A Test for Production of Plastic Fines in the Process of Degradation of Mineral Aggregates—Martin Ekse and Henry C. Morris

STP 277, 126 pages, hard cover, price $3.50, to members $2.80.

1959 Supplement to Bibliographical Abstracts of Methods for Analysis of Synthetic Detergents (STP 150-C)

(Available Now)

This latest supplement provides a thorough abstract coverage of the literature on methods for analysis of synthetic detergents for the years 1958 and 1959. A considerable number of papers for the years from 1933 through 1957 are also covered. This supplement therefore brings the original references, published in *STP 150-A*, up to date and covers additional references, not previously listed, back to 1933.

STP 150-C, 48 pages, heavy paper cover, price $2.00, to members $1.60.

1960 Supplement to the Metal Cleaning Bibliographical Abstracts (STP 90 E)

Sponsored by Committee D-12 on Soaps and Other Detergents

The volume of publications concerned with metal cleaning continues at a level comparable with previous years, but the emphasis has gradually changed. New metals present new cleaning problems which are solved by advanced techniques or combinations of older methods.

Over 100 references prior to 1958 have been found, those from 1958 to early 1960 totalling 114. As before, indexes of subject, author, specification, and patent number have been provided. Covered are the fields of practical application, laboratory evaluation, theory, and references from other fields applicable to the subject. This book supplements STP 90B, 90C, and 90D so that the years from 1842 to early 1960 are covered in these four books.

BRI Announces Program for Fall Conferences

Featuring a research correlation conference on preassembled components in modern building, the 1960 Fall Conference of the Building Research Inst. will be held at the Shoreham Hotel, Washington, D. C., Nov. 15–17. The three-day session will also include a conference on structural foams, a conference-workshop on fasteners and anchorage devices for industrial curtain walls, and a conference on building research developed by the Institute's Research Committee.

The program on preassembled components, which has been under development for the past year by the BRI Plastics Study Group, will first examine the attitudes toward this method of construction held by architects, home builders, general and specialty contractors, building owners and operators, organized and unorganized labor, and building code officials. A spokesman for each of these groups will present the views of his colleagues, their problems and successes with the use of components, and their suggestions for further improvement of methods, materials, and practices.

The second section of the program will deal with the principles of design and assembly of components for both residential and nonresidential construction, for prefabricated and site-constructed houses. Experience and cost data developed in production, distribution, and construction by building material dealers will be reported, as well as a review of manufacturers' experiences in combining materials to form preassembled components and the optimum level of preassembly of components for the most favorable manufacturing and distribution costs.

Rounding out the two-day conclave will be a series of case study reports on actual use of preassembled structural components, including window and door components, wall and partition systems, and a special group of case studies on preassembled mechanical components, electrical systems, and utility cores.

The conferences on structural foams, on Wednesday, Nov. 16, will include a session on foamed inorganic materials, including glass, concrete, and metals, followed by a session on foamed organic materials such as the polyurethanes and polystyrenes in their application to thin-shell construction.

Fasteners for industrial curtain walls will be discussed in a conference-workshop, with specialists participating in a closed workshop for a day and a half, and the balance of the second day thrown into an open meeting at which their conclusions will be reported.

ASTM Committee E-6 on Methods of Testing Building Constructions will hold a two-day meeting on Nov. 14 and 15 in conjunction with the BRI conferences. A half-day papers session on curtain wall construction will be included.

Information about registration or further details about the BRI conferences may be obtained from Harold Horowitz, assistant director for technical programs, Building Research Inst., 2101 Constitution Ave., Washington 25, D. C.

ASTM Bulletin

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Philadelphia 3, Pa.

MATERIAL QUESTIONS

NEARLY EVERY day the mail at ASTM Headquarters includes some questions about materials, specifications, test methods, or related problems. We feel that the answers, many of which are based on information given us by officers of committees in their capacity as committee officers, are of general interest. For the most part, inquiries we receive are related to the activities of the Society, either standards. research work, or publications. Often, an inquiry is such that the services of a consultant or independent testing or research laboratory is obviously required; in this event we do not hesitate to so recommend.

Materials Sciences—A New Bulletin Department

MATERIALS SCIENCES — a topic of rapidly growing interest—is the subject for a new department in the BULLETIN beginning in this issue (see p. 22). Readers may expect to see reported regularly the latest plans and programs of the Division of Materials Sciences, pertinent quotes on what others are saying about materials sciences, and general news on the subject from whatever source. The new department will provide a medium of communication for the Society's new division. Members of the division's executive committee may be expected to contribute on occasion, as well as others who have something to say about materials sciences.

The division's first activity—sponsoring two symposia at the 1960 Annual Meeting—aroused great interest, which has been expressed in letters to headquarters and to K. B. Woods, chairman of the division. Professor Woods and the executive committee are seeking broad participation in the division's activities by members of the Society, and to accomplish this it is necessary that members be informed about the division's plans. This will be a major objective of the new department, *Materials Sciences.*

Another objective of the department may seem a lofty one—we shall attempt by whatever means at our disposal through the column to help materials scientists and engineers to a mutual understanding. Both groups are well represented among the Society's membership. Both have much to learn from each other, as, indeed, scientists in one field can be stimulated by learning about findings in other, quite different fields. In these times of specialization it is not difficult to fall into a narrow viewpoint. The new division in its program planning will try to maintain a broad view, and through the columns of the new department we intend to help. F.Y.S.

Schedule of ASTM Meetings

This gives the lastest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
November 1–2	Committee B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts	Skytop, Pa. (Skytop Lodge)
November 2–4	Committee D-27 on Electrical Insulating Liquids and Gases	Williamsburg, Va. (Motor Lodge)
November 3	Committee E-13 on Absorption Spectroscopy	New York, N. Y. (Hotel New Yorker)
November 3	Committee F-2 on Flexible Barrier Materials	New York City (Statler)
November 3–4	Committee D-27 on Electrical Insulating Liquids and Gases	Williamsburg, Va.
November 3–4	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Skytop, Pa. (Skytop Lodge)
November 9	Philadelphia District	Newark, Del. (Univ. of Del.)
November 9–10	Committee D-15 on Engine Antifreezes	New York City (Statler)
November 10	Committee E-11 on Quality Control of Materials	Headquarters
November 14–15	Committee E-6 on Methods of Testing Building Constructions	Washington, D. C. (The Shoreham)
November 16–17	Committee C-17 on Asbestos Cement Products	Buffalo, N. Y. (Statler)
December 1	Committee E-1 on Methods of Testing	Philadelphia, Pa. (Society Headquarters)
December 5–6	Committee C-1 on Cement	Denver, Colo. (Brown-Palace Hotel)
December 7–8	Committee B-7 on Light Metals and Alloys, Cast and Wrought	Washington, D. C. (Sheraton-Park)
December 8–9	Committee C-9 on Concrete and Concrete Aggregates	Denver, Colo. (Brown-Palace Hotel)
	1961 Meetings	
January 20	Southern California District	Los Angeles, Calif.
January 23	Northern California District	San Francisco, Calif.
January 23–25	Committee A-1 on Steel	Pittsburgh, Pa. (Penn-Sheraton)
January 25–27	Committee D-19 on Industrial Water	Pittsburgh, Pa. (Penn-Sheraton)
January 30–February 3	Committee Week	Cincinnati, Ohio (Netherland-Hilton)

Fire Hazards of Plastics

Some underwriting questions have arisen regarding the plastics industry. It is difficult to classify the many new plastics as to their fire hazard and combustibility. We are trying to obtain this information. We have opportunities to write both plastics manufacturers and warehouses; however, we are not sure whether some of the plastics involved are hazardous or not.

Is it possible, by knowing the chemical components, to determine the combustibility of any particular plastic? Could you give us a breakdown showing which chemicals would make a plastic classify high, medium, or low in hazard?

● This is a very live subject, and while we cannot give you any pat answers, we can refer you to some sources of information, both within ASTM and elsewhere.

Much useful information is included in NBFU Research Report No. 1 (M 65), "Fire Hazards of the Plastics Industry—1955." This report, available from the National Board of Fire Underwriters, includes a list of chemical-type classifications for a number of proprietary plastics. It also includes a table of burning rates for various plastics types, based on ASTM small-specimen laboratory tests. We emphasize this small-specimen test because the results from this test, while serving as a convenient way to classify burning rates of materials according to the test, may not be indicative of the fire hazard of the plastic material when used in a structure.

A number of articles on the flame resistance of plastics have appeared in the technical and trade press, and one which you may want to look up was in *Modern Plastics*, Volume 37, No. 1, September, 1959.

As to your question concerning the determination of combustibility of plastics on a basis of chemical composition—this can provide useful information, though again, reliance on such information alone as a basis for classification of fire hazard is not safe. It is known that many plastics materials containing a high percentage of chlorine, fluorine, phosphorus, or nitrogen are likely to be slow-burning or flame-resistant. However, other factors enter also, such as the physical nature of the material, combination with other materials etc., as well as how it is used. The effect of composition upon burning rate is of more interest in research where the objective is to develop a fire-resistant plastic.

ASTM Committee E-5 on Methods of Fire Tests is responsible for the development of test methods for the determination of fire resistance and fire hazard of building materials and constructions irrespective of composition. This type of test method is used primarily by building code authorities as a basis for establishing ratings of materials and assemblies based on a time-temperature curve. The two outstanding standards referred to in most codes are: (1) Methods of Fire Tests for Building Construction and Materials (E 119), and (2) Methods of Test for Surface Burning Characteristics of Building Materials (Tunnel Test) (E 84 T). The latter method is primarily for interior finishes in buildings.

So-called "small-scale" fire test methods have been considered, and a method known as the radiant panel method is being presented to ASTM as a new tentative method. A modification of the E 84 T test, known as the small or 8-ft tunnel, is being published as information only as a proposed method.

The ASTM small-specimen tests for plastics and other flammability tests appear in the ASTM Book of Standards. They are listed in the Index to ASTM Standards under "Fire Tests" and "Flammability Tests."

Permeability of Carbon

Do you have a method for measuring the gaseous permeability of carbon electrode specimens?

● Committee C-8 on Refractories has completed interlaboratory collaborative studies on a carbon refractory permeability apparatus developed by the carbon industry. The gas used in this apparatus is nitrogen. It is expected that work on this test will be completed this year. The committee is also investigating modifications of this apparatus to test clay, silica, and high-alumina and basic brick.

Papers to Appear in Future Issues of the ASTM Bulletin

Punch Card Handling of Atmospheric Test Data—W. H. Ailor and M. R. Hodgson, Reynolds Metals Co.

A More Sensitive Test Method for Determining the Dielectric Strength of Insulating Oils—P. F. Ast, General Electric Co.

The Evaluation of Resistance Strain Gages at Elevated Temperatures—R. L. Bloss, National Bureau of Standards.

Properties of Some Copper Alloys at Elevated Temperatures—C. H. Crowe, Canadian General Electric Co., Ltd.

Use of Stormer Viscometer for Testing Rotogravure and Flexographic Inks and Use of a Modified McMichael Viscometer for Consistency of Printing Inks and Ink Vehicles—Ross Cummings, The California Ink Co.

Subsize Charpy Correlation with Standard Charpy—C. H. Curll, Watertown Arsenal Laboratories.

Determination of the Mechanical Properties of Elemental Sulphur—J. M. Dale, Sr., Southwest Research Inst.

The Permeability of Sand Stabilized with a Chemical Grout—G. H. Dorion, H. Burkhard, M. L. White, American Cyanamid Co.

A Short Method for the Flame Photometric Determination of Magnesium, Manganic, Sodium and Potassium Oxides in Portland Cement—C. L. Ford, Portland Cement Assn.

Fracture Characteristics of Notched Tensile Specimens of Titanium and a Titanium Alloy—G. W. Geil and N. L. Carwile, National Bureau of Standards.

Influence of Particle Size Distribution of Sand on Strength and Workability of Vibrated Mortar—F. Giuliani and R. Suarez, University of Cuyo.

A Method for Determining the Impact Sensitivity Characteristics of Materials with Highly Reactive Oxidizers—R. Kopituk, Thiokol Chemical Corp.

Detection of Glycols in Crankcase Oils—C. B. Jordan, Coating and Chemical Laboratory, U. S. Army.

Workability of Masonry Mortar—L. Kampf, Borough of Queens, N. Y.

Predicting Weatherability of Coating Grade Asphalts from Asphaltene Characteristics—E. W. Mertens, California Research Corp.

Portable Adhesion Testing Device—B. M. O'Kelly, National Research Council.

A Stainless Steel for Standard Weights—S. J. Rosenberg and T. P. Royston, National Bureau of Standards.

A Simple Stress-Corrosion-Cracking Test for Copper Alloys—D. H. Thompson, American Brass Co.

OFFERS OF PAPERS FOR 1961

THE Administrative Committee on Papers and Publications will meet in early February to consider the papers to be published by the Society in 1961 and to develop the program for the Annual Meeting to be held in Atlantic City June 25–30.

All those who wish to offer papers for presentation at the meeting and publication by the Society should send these offers to Headquarters *not later than January 10, 1961.*

All offers should be accompanied by a summary that makes clear the intended scope of the paper and indicates features of the work that will, in the author's opinion, justify its publication and inclusion in the Annual Meeting program.

Suitable blanks for use in transmitting this information will be sent promptly upon request to Headquarters.

Materials Sciences

Editor's Note: This is a first. With this issue of the BULLETIN, a new regular department, *Materials Sciences*, is born. Its *raison d'être* and our hopes for its future will be found in the editorial on page 20.

Practical Men and Dreamers

"Like all sciences that arise late, the physics of solids has the disadvantage of running behind technology. People . . . use solids all the time, and in doing so, must acquire some sort of technological control over their properties. In such a situation, the practical man is apt to despise the dreamers who try to 'understand' features which he takes for granted. It looks, however, as if this kind of attitude is about to run out. Theoretical analysis is beginning to produce solids with properties beyond the 'common sense' experience of the practical man. [Many] spectacular results are destined to flow from this painstaking study of what has long seemed a dense and commonplace subject."

G. H. Wannier, Bell Telephone Laboratories, Inc., in Scientific American, *December, 1952, p. 48.*

Purity

"Having approached as close as we can to ideal purity, having studied a substance in its purest form and having characterized its properties, we may then begin to understand how these substances are altered by the addition of minor constituents in highly precise amounts or by a change in the atomic lattice. In this way we may surely develop new basic knowledge of the structure and character of matter."

A. V. Astin, director, National Bureau of Standards, in an address before The American Chemical Society, December, 1958.

Effects of Trace Elements

"Effects of Trace Elements on Properties of High-Purity Materials" is the proposed subject for a two-session symposium planned for the 1961 Annual Meeting in June. The symposium—the second major activity of the Division of Materials Sciences—is being arranged jointly by I. V. Williams and John Sullivan, assisted by Frank LaQue, A. C. Webber, and ASTM President A. Allan Bates—all members of the division's executive committee. Being mindful that the 1960 Annual Meeting sessions were heavy on crystalline solids, especially metals, the committee will solicit papers not only on pure metals and ceramics but on organic materials and high polymers and liquids and gases. Objectives of this broad program are several: to show that materials provide a common denominator for science in an interdisciplinary approach, to digest the state of knowledge of pure materials, and to focus attention generally on the problems and accomplishments in the materials sciences.

The Past is Prologue

This is only the beginning. Papers from the 1960 sessions on Recent Progress in Materials Sciences and Nature and Origin of Strength of Materials are being edited for publication in a special volume. More on this in later *Materials Sciences* columns in the BULLETIN.

Plans are afoot for materials sciences programs for Committee Week, 1962 in Dallas, and for the 1962 Annual Meeting in New York. The program committees will be selected from other than the members of the executive committee.

You Too Can Be a Men.ber

The bylaws state that all members of the Society are eligible to participate in the activities of the division. Plans are to establish a membership roster for the division—no extra dues are involved—to allow members of the Society to indicate their active interest in materials sciences. Watch this column for more on this subject.

This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

JOHN BUTLER JOHNSON (1850–1902). Born in Ohio, John Butler Johnson became professor of civil engineering at Washington University and dean of the Engineering College at the University of Wisconsin. He was joint author of a series of books on bridges and author of a monumental work, *Materials of Construction*, which is a storehouse of information on the properties of materials. An ourstanding man, Johnson also pioneered in the testing of timber.

"The engineer is of necessity a scientific investigator. He should be taught the scientific methods of experimentation throughout his entire course, while studying the pure sciences as well as their applications. In fact his most valuable college acquisition is his having learned how to learn."

Regents Bulletin

District Activities

Coming District Meetings

District	Place	Date	Program
New England	Boston, Mass.	October 27	Automation Panel
Mississippi Valley	St. Louis, Mo.	October 27	R. W. Seniff
Rocky Mountain	Tucson, Ariz.	November 2	A. A. Bates
Philadelphia	Newark, Del.	November 10	A. A. Bates
Washington	Washington, D. C.	November 14	Kurt Stehling
Detroit	Detroit, Mich.	November 17	Panel Discussion

SOUTHERN CALIFORNIA

Design of New Auto Described

Edward H. Kelley, general manufacturing manager of the Chevrolet Motor Division of General Motors Corp., speaking before a joint meeting of the Southern California District of ASTM and the Los Angeles Chapter of the American Society for Metals on Sept. 22, described the design and production organization that conceived and produced the Corvair automobile. In his talk, Mr. Kelley detailed the extensive collaboration that existed between the design and production facilities and the teamwork that was necessary to place this car on the assembly line.

Discussing the major problems concerned with the start-up of Corvair production, he described plans that integrated the efforts of an aluminum foundry at Massena, N. Y., an engine plant at Buffalo, N. Y., and assembly plants throughout the nation.

Mr. Kelley has been associated with General Motors since 1928, when he joined the Chevrolet Division as a designer. During World War II he served as chief engineer of the Chevrolet Aviation Division at Tonawanda, N. Y. Since 1952 he has held his current position as general manufacturing manager.

The joint meeting, held at Rodger Young Auditorium in Los Angeles, was well attended by members of both societies. A social hour and dinner preceded the talk given by Mr. Kelley.

Northwest District Being Formed

The Board of Directors of the Society at its meeting on Sept. 13 approved the formation of a Northwest District, composed of Idaho, Oregon, Washington, and British Columbia.

The new district is the eighteenth district for the Society. All Continental United States with the exception of four Central Plains States and a portion of Kansas are now served by district councils. A provisional Council for the Northwest District is in the process of formation, and it is hoped that the new district will be in operation by midwinter.

St. Louis District Now Mississippi Valley District

Better to describe the area served, the name of the St. Louis District has been changed by action of the Board of Directors to Mississippi Valley District. This action was taken on recommendation of both the local council and the Administrative Committee on District Activities.

ACDA Plans Changes in Charter

THE ADMINISTRATIVE COMMITTEE on District Activities, at a meeting on September 14 at National Headquarters, heard the report of a task force which has undertaken a complete revision of the Charter and Manual for Districts. The committee hopes to make a new charter available to district councilors within the next year to 18 months. It is hoped that, with the publication of the new charter, the district councils will be strengthened so that they may take more independent action. Also, the Administrative Committee on District Activities will be better prepared to offer guidance in meeting the objectives of the entire district program. As a result, all districts will be able to take a more active role in Society affairs by sponsoring significant technical meetings, by generating interest among students and young graduates in the purposes of the Society, and by encouraging the active participation of members in the work of the Society both at the local and national levels.

In an effort to include all ASTM members living in the continental United States in districts, a task force has been organized to study carefully the boundaries of existing districts and to study the feasibility of establishing districts in areas not now served. The first recommendations are expected to be made to the Board of Directors at their meeting in January, 1961.

Plans are being made to devote an entire evening session of the 1961 Annual Meeting to topics of concern to those interested in districts and their operation. This program will supersede the breakfast formerly sponsored by the ACDA and will be open to district officers, councilors, and all others interested in developing this program to its full potential.

Index to Paint Tests, Guide to Selection of Paint Specifications Published

The thousands of paint materials and paint products now being manufactured require such a diversity of test methods that it is not always easy to track down the best method for a given test. A Comprehensive Index of Methods of Test for Paints and Paint Materials, just published by the Federation of Societies for Paint Technology, should make it easier. The index includes FSPT-approved methods, ASTM methods, Federal Standard 141 and other federal specifications, and methods appearing in the Canadian Government Specifications Board Methods of Testing Paints and Pigments, 1-GP-71a, plus some of the amendments thereto. A new edition of the Canadian methods, 1-GP-71, was published in May, 1960. Copies of the 64-page index are available from ASTM Headquarters at $1 each.

A "Guide to the Selection of Paint Specifications on Use Basis," published by the National Research Council of Canada, became available early this year. This guide lists all paint specifications issued by the Canadian Government Specifications Board, defines the material, and gives the intended use for each. Copies may be obtained from the Canadian Government Specifications Board, National Research Council, Ottawa, Canada. The price is $3.

The number of standards adopted per year by ASTM, along with everything else in this world of exploding technologies and populations, is growing rapidly, as witness the following:

Years	Average Number of Standards Adopted per Year by ASTM
1902 to 1910	3.5
1910 to 1930	27
1930 to 1950	57
Currently	78

Technical Committee Notes

Additional SBR and SBR Latex Announced by Committee D-11

Subcommittee XIII on Synthetic Elastomers of Committee D-11 on Rubber and Rubber-Like Materials announces three new styrene-butadiene rubbers (SBR) and one new SBR latex brought on the market recently. Assignment of numbers is in accordance with the Tentative Recommended Practice for Description of Styrene-Butadiene Rubbers (SBR) and Butadiene Rubbers (BR) (D 1419 – 60a T) and the Tentative Recommended Practice for Description of Types of Styrene-Butadiene Rubber (SBR) and Butadiene Rubber (BR) Latices (D 1420 – 59 T).

The new SBR numbers and the corresponding product descriptions are shown in the table below.

ASSIGNMENT OF NEW CODE NUMBERS FOR STYRENE-BUTADIENE RUBBERS AND BUTADIENE RUBBER LATEX

Number assigned....	1609	1816	1817	2114
Date assigned.....	6/6/60	8/15/60	8/15/60	6/7/60
Requested by.....	General Tire and Rubber, Phillips Chemical	General Tire and Rubber	General Tire and Rubber	Goodyear
Distinctive feature.....	SAF, dispersant-free	ISAF black dispersant - free oil master batch	SAF black dispersant - free oil master batch	68 per cent min total solids content
Close previous number, if any.....	Gentro-Jet 9152 Phillips 6604	Gentro-Jet 9250	Gentro-Jet 9252	...
Type.....	1600	1800	1800	2105
Nominal temperature, deg Fahr.....	43	43	43	50
Activator.....	FRA	FRA	FRA	FRA
Shortstop.....	ND	ND	ND	ND
Antioxidant.....	ST	ST	ST	...
Catalyst.....	OHP	OHP	OHP	OHP
Emulsifier.....	RA	Mixed	Mixed	FA
Nominal bound styrene, per cent.....	23.5	23.5	23.5	24
Nominal conversion, per cent.....	60	60	60	...
Nominal Mooney viscosity, ML 1 + 4 (212 F), polymer.....	...	...	...	120[a]
Nominal Mooney viscosity, ML 1 + 4 (212 F), compound.....	61	55	50	...
Coagulation.....	acid	acid	acid	...
Carbon black:				
Type.....	SAF	ISAF	SAF	...
PHR.....	40	70	55	...
Oil:				
Type.....	HI-AR	HI-AR	HI-AR	...
PHR.....	5	45	45	...
Finishing.....	normal	normal	normal	...
Nominal residual volatile unsaturate, per cent.....	...	...	...	0.10
Nominal pH value.....	...	...	...	10.0
Nominal surface tension, dynes per cm.....	...	...	...	...
Nominal coagulum on No. 80 screen, per cent	...	...	...	0.10
Nominal total solids, per cent.....	...	...	...	68

[a] Difficult to measure accurately.

NOTE.—Abbreviations and symbols are defined as follows: FA = Fatty acid. FRA = Free radical type, that is, iron pyrophosphate, peroxamine sulfoxylate. HI-AR = Highly aromatic. ND = Nondiscoloring. OHP = Organic hydroperoxide. RA = Rosin acid. SAF = Superabrasion furnace. ISAF = Intermediate superabrasion furnace. ST = Staining.

Cellulose Acetate Test Methods Undergoing Major Revision

Committee D-23 on Cellulose and Cellulose Derivatives is preparing major revisions of the Methods of Testing Cellulose Acetate (D 871) for presentation to the Society in 1961. The revisions include new methods for heat stability, hydroxyl content, primary hydroxyl content, sulfur or sulfate content, intrinsic viscosity, color, and haze; an improved method for acetyl content is also being prepared. Similar revisions are being considered for the Methods of Testing Cellulose Acetate Butyrate (D 817), which will also increase the coverage of the method to include cellulose acetate propionates.

A new method for degree of etherification of refined sodium carboxymethylcellulose (NaCMC) is being proposed for Method D 1439. This procedure is based on the nonaqueous acid-base reaction of a sodium salt of a weak acid, using dioxane as a solvent and titrating with perchloric acid using the potentiometer to determine the end point. Since this method does not distinguish between the sodium in the CMC and in any other impurities, it is applicable only to the refined Na-CMC; this is not now covered in Method D 1439. A method to determine the sodium glycolate content colorimetrically using 2,7-dihydroxynaphthalene as the color forming agent is also being prepared for inclusion in Method D 1439.

The work of several years has resulted in the proposal of the chromatographic method of analysis of chemically refined cellulose pulps. This method using paper chromatography procedures is being prepared for presentation as tentative in 1961.

Other methods under development are a whiteness test for refined cellulose, a test for constituents of cellulose ash, two methods for determination of carboxyl content and carbonyl content of refined cellulose, and a method for degree of substitution of NaCMC.

Sixth International Conference on Hot-Dip Galvanizing

The sixth in the series of International Conferences on Hot Dip Galvanizing is to be held at the Kursaal, Interlaken, Switzerland, June 4–9, 1961.

Three days will be devoted to technical sessions at which over 25 papers will be presented on works practice, the properties and corrosion resistance of galvanized coatings, the welding of galvanized steel, the metallurgy of galvanizing, after-treatments, and the heating of galvanizing baths. One session will also be devoted to sheet galvanizing. Preprints of the papers will be issued in French, German, Italian, and English, and there will be simultaneous translation into the same four languages at the technical sessions themselves.

Those wishing to attend the conference as delegates or to participate in the exhibition of plant, equipment, and materials should write to the Zinc Development Assn., 34 Berkeley Square, London, W. 1.

Low-Temperature Tensile-Hardness Correlations for SAE 4340 Steel[1]

By J. NUNES and F. R. LARSON

Vickers hardness (DPH) and tensile strength (UTS) were studied on one heat of SAE 4340 steel as a function of testing temperature. Tempered martensite, bainite, and pearlite of various strength levels were tested at a temperature range of room temperature to −196 C. It was found that these two variables (DPH and UTS) are linear with respect to the reciprocal absolute temperature. Furthermore, the various strength levels formed a family of parallel lines. From this, it is possible to derive some simple empirical equations for calculating approximate values of DPH or UTS in the temperature range studied.

Further, it was established that, for SAE 4340 steel, the SAE hardness–tensile-strength correlation for room temperature is reasonably valid in the range of temperature studied.

BECAUSE of the recent engineering interest in the properties of materials at low temperatures, this investigation into two important mechanical properties, hardness and tensile strength, was made. It was believed that some useful data could be obtained on the low-temperature behavior of these two properties if they were found for a commercially important material, such as SAE 4340 steel. Further, it is hoped that the low-temperature behavior of this material may be typical of other quenched and tempered steels, as it has been shown to be in the case of room-temperature hardness–tensile-strength correlations (**1, 2, 3**)[2]

The Vickers diamond pyramid hardness (DPH) was used in this investigation because of the linear relation that exists between it and tensile strength in the range of hardness of DPH 240 to 680.[3] Furthermore, the Vickers hardness method is theoretically insensitive to the applied load and can be used over a relatively wide range of strength levels.

Primarily, this investigation was conducted to determine whether a relationship could be established between hardness and testing temperature, and whether the linear hardness–tensile-strength relation is valid at the lower testing temperatures.

Materials and Procedure

The material used in this investigation was one heat of SAE 4340 steel heat treated to several hardness levels and structures (bainite, tempered martensite, and pearlite). Chemical analyses and heat treatments are given in Tables I and II, respectively.

TABLE I.—CHEMICAL ANALYSES.

Composition, weight per cent	
Carbon	0.375 to 0.385
Manganese	0.75 to 0.77
Silicon	0.32 to 0.33
Sulfur	0.020 to 0.023
Phosphorus	0.008 to 0.009
Nickel	1.75 to 1.80
Chromium	0.79 to 0.80
Molybdenum	0.24 to 0.26
Vanadium	Trace

ASTM standard testing procedures were followed in determining Vickers hardness numbers.[3] A Vickers-Armstrong pyramid hardness testing machine and a 50-kg load were used. Specimens were machined from heat-treated $\frac{5}{8}$-in. sq by $2\frac{1}{2}$-in.-long blanks. All hardness readings from each heat treatment were obtained on one specimen, enabling greater accuracy in the determination of the relative increase in hardness due to lowered testing temperatures.

A thermocouple was inserted into a dummy bar placed near the specimen. All tests were conducted after the specimen and indenter were in the coolant for 15 min or longer at the required testing temperature. Measurements of the impressions were made after the specimen had returned to room temperature.

A minimum of four hardness readings was obtained at each testing temperature with the average of these taken as the hardness value. Of the four readings taken, the deviation was less than 1 per cent. Specimens were tested in a temperature range of room temperature to −196 C. The methods used to obtain these testing temperatures are outlined in Table III.

Results and Discussion

Hardness Versus Testing Temperature

The average hardness value obtained at the various testing temperatures are

JOHN NUNES is a materials engineer at the Watertown Arsenal Laboratories, Watertown, Mass. He has been engaged in the study of the mechanical properties of steel and titanium-base alloys since 1956. Currently, he is engaged in the study of the plastic flow and fracture of metals as influenced by testing temperature, material composition, and strain rate. He is a graduate of Boston University with a B.S. in aeronautical engineering.

FRANK R. LARSON is chief of the Mechanical Metallurgy Branch, Watertown Arsenal Laboratories. As a physical metallurgist, his primary interests since 1946 have been in the mechanical metallurgy of ferrous metals and titanium-base alloys with major emphasis on plastic flow and fracture.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The statements and opinions expressed in this article are those of the authors and do not necessarily indicate the views or policy of the Army Ordnance Corps.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] ASTM Method of Test for Diamond Pyramid Hardness of Metallic Materials (E 92 – 57), 1958 Book of ASTM Standards; Part 3, pp. 52–57.

TABLE II.—HEAT TREATMENT, SAE 4340 STEEL.

Series	Normalize	Austenitize	Temper	Stress Relief
		TEMPERED MARTENSITE		
D	...	1525 F, 1 hr	Marquenched 430 F (hot salt), 5 min; air cooled; 765 F, 2 hr; oil quenched	...
E	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	1035 F, 1½ hr; oil quenched	570 F, 3 hr; air cooled
F	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	1250 F, 1½ hr; water quenched	570 F, 3 hr; air cooled
P	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	1100 F, 1½ hr; water quenched	570 F, 3 hr; air cooled
S	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	900 F, 1½ hr; water quenched	570 F, 3 hr; air cooled
T	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	500 F, 1½ hr; water quenched	...
U	1650 F, 1 hr; air cooled	1600 F, 1 hr; oil quenched	500 F, 1½ hr; double-temper water quenched	...
		PEARLITE		
M and N	1650 F, 1 hr; air cooled	1550 F, 4 hr	Slow cooled to 1200 F, 48 hr; furnace cooled	...
O	1650 F, 1 hr; air cooled	1550 F, 4 hr	Slow cooled to 1100 F, 48 hr; furnace cooled	...
		BAINITE		
J	...	1550 F, 1½ hr	740 F (hot salt) 24 hr; oil quenched	...
K	...	1550 F, 1½ hr	650 F (hot salt) 4 hr; oil quenched	...

TABLE III.—COOLANTS USED FOR DIFFERENT TEST TEMPERATURES.

Temperature, deg Cent	Dry Ice	Alcohol	Isopentane	Liquid Nitrogen	Remarks
− 40	X	X	...	...	Alcohol mixed with dry ice
− 80	X	X	...	...	
−105	...	...	X	X	Liquid nitrogen cools isopentane to required temperature
−130	...	...	X	X	
−150	...	...	X	X	
−196	...	...	...	X	At liquid nitrogen temperature

TABLE IV.—VICKERS DIAMOND PYRAMID HARDNESS AT VARIOUS TESTING TEMPERATURES FROM ROOM TEMPERATURE TO −196 C.

Series	Room Temperature	−40 C	−80 C	−105 C	−130 C	−155 C	−196 C
T	553	569	584	585	600	621	696
U	544	563	574	597	605	610	708
D	482	487	508	521	539	565	632
K	431	444	450	462	492	503	563
S	414	422	448	459	486	490	564
E	362	373	399	411	434	466	530
J	347	358	374	391	422	431	505
P	325	344	363	361	401	432	487
F	284	295	313	324	354	371	443
O	209	219	234	255	278	296	388
M	192	204	220	235	253	284	353
N	194	209	222	244	267	278	358

shown in Table IV and in Fig. 1. In Fig. 1, where hardness is plotted versus the reciprocal of absolute temperature, the data form reasonably straight lines. Furthermore, the various strength levels (or heat treatments) form a family of relatively parallel lines. It is apparent that changing the testing temperature changes the hardness by an amount that is constant for all strength levels.

It is felt that, since the temperature dependence of hardness is independent of the metallurgical structure and the strength level, and since it is known that the temperature dependence of tensile and yield strengths are functions of composition (4), this hardness change with temperature must also be dependent upon composition.

In the light of these data, it is now possible to establish a simple empirical equation relating hardness to temperature for this steel as follows:

$$DPH = \frac{M}{T} + C \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

DPH = Vickers diamond pyramid hardness,
M = slope of hardness-temperature curve,
T = absolute testing temperature in deg Kelvin, and
C = material constant or intercept at $\frac{1}{T} = 0$.

Assuming Eq 1 to be valid, the slopes (M) and intercepts (C) were calculated by the least-squares method and are tabulated in Table V. It can be seen that the slopes are reasonably constant, with less than ±8 per cent standard deviation, and that the strength level enters Eq 1 through the material constant (C).

Calculation of the low-temperature hardness from the more available data at room temperature would be more convenient with Eq 1 expressed in terms of the room-temperature hardness as follows:

$$DPH_T = M\left(\frac{1}{T} - \frac{1}{RT}\right) + DPH_{RT} \ldots (2)$$

where:

DPH_{RT} = Vickers diamond pyramid hardness at temperature T,
RT = room temperature, deg Kelvin, and
DPH_{RT} = Vickers diamond pyramid hardness at room temperature.

This means that, assuming Eqs 1 and 2 to be correct, it is possible to obtain a reasonably accurate hardness value at the lower testing temperatures (RT to −196 C), knowing only the room-

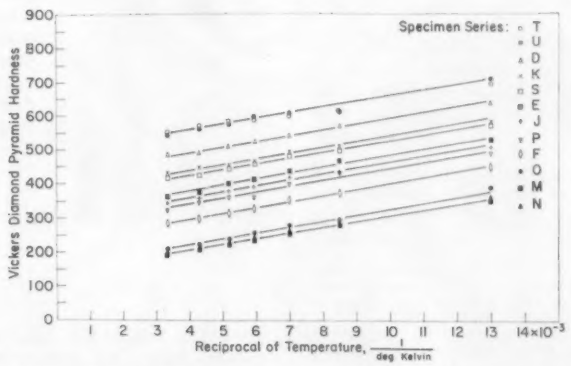

Fig. 1.—Vickers diamond pyramid hardness versus reciprocal of absolute temperature.

TABLE VI.—ULTIMATE TENSILE STRENGTH, PSI, AT VARIOUS TESTING TEMPERATURES FROM ROOM TEMPERATURE TO −196 C.

Series	Room Temperature	−40 C	−80 C	−105 C	−130 C	−155 C	−196 C
T	265 400	...	...	...	...	297 800	315 000
U	261 600	261 600	274 600	281 600	289 500	286 600	306 400
D	229 000	227 000	234 800	237 700	250 000	263 700	276 100
K	198 700	202 400	209 500	214 800	222 600	222 500	249 200
S	192 200	200 200	206 000	...	217 100	227 700	244 400
E	163 000	178 000	182 300	188 100	198 700	201 900	225 100
J	163 500	169 200	174 000	180 000	190 200	197 000	213 000[a]
P	146 700	155 600	160 700	...	173 100	184 500	207 500
F	124 800	135 000	142 500	148 300	156 700	167 400	184 600
O	107 800	...	...	...	...	...	160 700
M	95 800	104 700	111 800	120 600	125 500	133 000	...
N	97 000	106 900	118 100	...	127 700	...	...

[a] Specimen broken before maximum load.

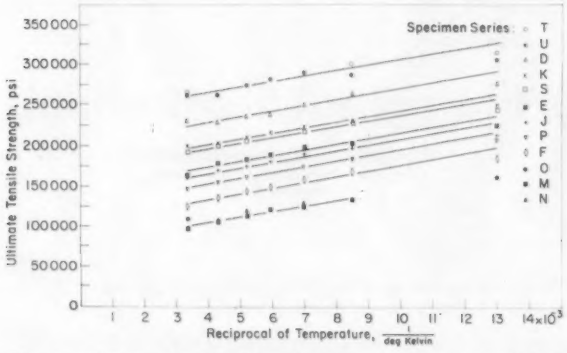

Fig. 2.—Ultimate tensile strength versus reciprocal of absolute temperature.

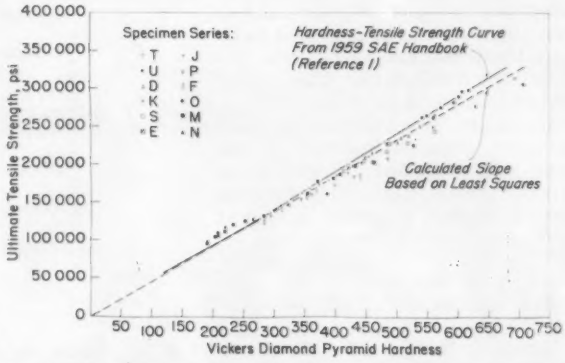

Fig. 3.—Ultimate tensile strength versus Vickers diamond pyramid hardness for SAE 4340 steel at testing temperatures of room temperature to −196 C.

TABLE V.—SLOPE (M) OF HARDNESS-TEMPERATURE CURVE AT INTERCEPT (C) (CALCULATED BY THE LEAST-SQUARES METHOD).

Series	M, DPH deg Kelvin	C, DPH
T	14.6×10^3	503
U	16.3	490
D	16.2	424
K	14.1	383
S	15.7	357
E	18.0	304
J	16.8	291
P	17.3	271
F	16.9	226
O	19.0	140
M	17.2	133
N	17.1	138

$M_{average} = 16.6 \times 10^3$ DPH deg Kelvin.
Standard deviation = $\pm 1.3 \times 10^3$ DPH deg Kelvin.
Per cent standard deviation = ±7.8 per cent.

temperature hardness, DPH_{RT}, and the slope, M.

Tensile Strength Versus Testing Temperature

Ultimate tensile strength data for this material, obtained from a previous investigation into the plastic-flow and fracture properties of this steel (**5**), are listed in Table VI and graphically illustrated in Fig. 2. As would be expected, on the basis, that the hardness–tensile-strength correlation is valid at low testing temperatures, the ultimate tensile strength follows a pattern similar to that of hardness. There is, however, a discrepancy at the lowest testing temperature of −196 C. This discrepancy does not appear in the hardness results, which would seem to indicate that the different test system employed for the tensile tests contributed to the lower values of tensile strength at this temperature. Furthermore, ductility values as measured by elongation and true strain at maximum load were not significantly changed from those obtained at room temperature.

It would then seem that the lowered values of tensile strength observed could be attributed to heat and nonisothermal test condition at the neck, for the following reasons:

1. The temperature difference is greatest at this lowest temperature, which would probably result in greater heat losses through the specimen holders.
2. The higher stresses encountered at these low testing temperatures would cause a greater amount of plastic deformation work. Since approximately 95 per cent of this work would show up as heat generated in the specimen, complete adiabatic conditions may not have been present at these lower temperatures.
3. Because of the large sensitivity of stress to temperature in this low temperature range, a small increase in specimen temperature would cause an appreciable lowering of the tensile strength.

Assuming that the foregoing is a reasonable explanation of the lower ultimate tensile strengths at −196 C, and that these points are in error, an empirical equation similar to Eq 1 can be derived for tensile strength as follows:

$$UTS = \frac{N}{T} + C_1 \quad \ldots\ldots (3)$$

where,

UTS = ultimate tensile strength, psi,
N = slope of tensile strength-temperature curve, and
C_1 = material constant, or intercept at $\frac{1}{T} = 0$.

Following the method used for hardness, Eq 3 can be expressed in terms of room-temperature tensile strength. Knowing the slope, N, the ultimate tensile strength at any testing temperature, in the temperature range studied, can be determined. This equation is as follows:

$$UTS_T = N\left(\frac{1}{T} - \frac{1}{RT}\right) + UTS_{RT} \quad (4)$$

where:

UTS_T = ultimate tensile strength at temperature T, psi,
RT = room temperature, deg Kelvin, and
UTS_{RT} = ultimate tensile strength at room temperature.

Listed in Table VII are the values obtained for N and C_1. As with hardness, the slopes are reasonably constant, with less than ±9 per cent standard deviation.

Hardness Versus Tensile Strength

To establish the hardness–tensile-strength correlation, the hardness and tensile strengths obtained at equivalent testing temperatures were plotted as

TABLE VII.—SLOPE (N) OF TENSILE STRENGTH-TEMPERATURE CURVE AND INTERCEPT (C_1) (CALCULATED BY THE LEAST-SQUARES METHOD).

Series	N, psi/deg Kelvin	C_1, psi
U	84.9×10^3	241 300
D	73.5	198 400
K	67.4	174 800
S	68.3	170 000
E	75.2	142 400
J	69.0	139 600
P	72.4	123 100
F	82.6	98 600
M	74.0	73 000
N	84.8	70 300

$N_{average} = 75.2 \times 10^3$ psi/deg Kelvin.
Standard deviation = $\pm 6.4 \times 10^3$ psi/deg Kelvin.
Per cent standard deviation = ±8.5 per cent.

illustrated in Fig. 3. Superimposed on this plot is the room-temperature hardness–tensile-strength curve from the *1959 SAE Handbook* (1). The average slope for these plots (Figs. 1 and 2) was obtained by calculating each slope at each testing temperature by the least squares method and getting the average of these slopes. This calculated average slope is in general agreement with previous work done by Tabor (6) in calculating a hardness–tensile-strength correlation based on theoretical considerations such as strain-hardening properties and yield stress.

Although the general trend of the experimental slope derived here is slightly lower than the SAE slope, it can be said that the experimental slope approximates the SAE slope, within the limits imposed, because it is for one material composition while the SAE slope has been established by tests of a wide variety of compositions. The values obtained for the slope and the intercept at $DPH = 0$ were found to be approximately 465 psi per DPH and −2000 psi, respectively.

To illustrate the low-temperature independence of the hardness–tensile-strength correlation more clearly, data have been included in Fig. 4 for other ferrous alloys of different alloy compositions as taken from an ASTM publication by Gillett (7). It can be seen that these data points are above the SAE curve and do not display any general temperature dependence. This seems to indicate that the SAE hardness–tensile-strength correlation would be valid for temperatures below room temperature, within the limits currently used for obtaining approximate values of tensile strength with respect to hardness at room temperature.

Based on the data now available for the hardness–tensile-strength slope of SAE 4340 steel, a simple equation for obtaining the approximate tensile strength can be expressed.

Assuming that:

$$\text{UTS} \propto \text{DPH}$$

therefore:

$$UTS = 465\ DPH \quad \ldots\ldots (5)$$

TABLE VIII.—CALCULATED TENSILE STRESS (UTS_C) AND EXPERIMENTAL TENSILE STRESS (UTS) AS A FUNCTION OF TESTING TEMPERATURE.

Series Identification		Room Temperature	−80 C	−130 C	−155 C
U	UTS_C	253 000	266 900	280 900	292 000
	UTS	261 600	274 600	289 500	286 600
D	UTS_C	224 100	238 100	252 000	260 400
	UTS	229 000	234 800	250 000	263 700
E	UTS_C	168 300	182 300	194 100	205 200
	UTS	163 000	182 300	198 700	201 900
F	UTS_C	132 100	146 000	158 200	171 100
	UTS	124 800	142 500	156 700	167 400
J	UTS_C	161 400	175 300	187 200	200 400
	UTS	163 500	174 000	190 200	190 200
N	UTS_C	90 200	104 200	116 800	129 300
	UTS	97 000	118 100	127 700	...[a]

[a] Fractured in threads.

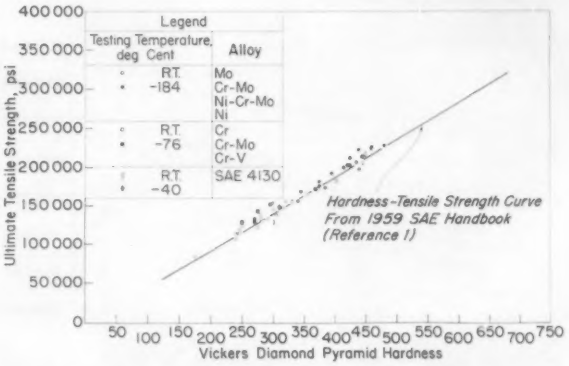

Fig. 4.—Ultimate tensile strength versus Vickers diamond pyramid hardness of some alloy steels at testing temperatures of room temperature, −40, −76, and −184 C, taken from Gillett (7).

Equation 5 can now be expressed in terms of room-temperature hardness in such a manner that only the slope, M, and the room-temperature hardness, DPH_{RT}, need be known. By substituting Eq 2 into Eq 5, the formula for tensile strength at temperatures below room temperature takes the form:

$$UTS_T = 465\left[M\left(\frac{1}{T} - \frac{1}{RT}\right) + DPH_{RT}\right] \quad (6)$$

Evaluation of Eq 6 was made by calculating from the room-temperature hardness several ultimate tensile strengths at different temperatures and strength levels. These are compared with the actual experimental values in Table VIII.

Conclusions

Based on the data presented, the following conclusions can be drawn.

1. Vickers hardness (DPH) is a linear function of reciprocal absolute temperature for SAE 4340 steel within a temperature range of room temperature to −196 C; the function takes the form:

$$DPH = \frac{M}{T} + C$$

2. A formula expressing Vickers hardness at any temperature between room temperature and −196 C, independent of the strength levels and structures studied, takes the form:

$$DPH_T = M\left(\frac{1}{T} - \frac{1}{RT}\right) + DPH_{RT}$$

3. Tensile strength (UTS) is a linear function of reciprocal absolute temperature; the function similar to that of Vickers hardness, takes the form:

$$UTS = \frac{N}{T} + C_1$$

4. A formula expressing tensile strength at any temperature between room temperature and −155 C independent of the strength levels and structures studied takes the form:

$$UTS_T = N\left(\frac{1}{T} - \frac{1}{RT}\right) + UTS_{RT}$$

5. Vickers hardness is a linear function of the testing temperature in the range studied (room temperature to −196 C) independent of the heat treatment and structures used in this experiment (martensite, bainite, and pearlite).

6. The above correlation of Vickers hardness with tensile strength is in agreement with the SAE correlation (1) and also with other low-temperature data points for other steels, indicating that this correlation may be valid for most steels and is apparently independent of testing temperature.

7. A formula for obtaining the approximate tensile strength of SAE 4340 steel at the lower testing temperatures may be derived in such a manner that only the room-temperature hardness and the hardness–reciprocal-temperature slope, M, of the steel need be known:

$$UTS_T = 465\left[M\left(\frac{1}{T} - \frac{1}{RT}\right) + DPH_{RT}\right]$$

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Lightfastness Testing of Pigment Colors*

By W. F. SPENGEMAN and G. WORMALD

THE SUBJECT of accelerated weathering of protective and decorative coatings has been reviewed at some length by many investigators. Among them, Arlt (1)[1] and Beck (2) conclude, in essence, that accelerated weathering techniques yield reliable results only when used with a considerable background of comparative tests based on exterior exposure. Beck concludes that "only changes in color and appearance, such as darkening, fading and chalking can be well correlated with outdoor exposure."

Approval for use of specific colored pigments in durable exterior finishes is generally based on their performance under actual outdoor exposure conditions. However, reliable accelerated lightfastness performance and its measurement are of major interest to both manufacturers and users of colored pigments. The destructive character of ultraviolet radiation is considered a major factor influencing the lightfastness of colored pigments. Accordingly, accelerated exposure devices equipped with high ultraviolet-emitting light sources, with or without water sprays, are in common use. In spite of their widespread use, however, published quantitative correlations of accelerated and actual outdoor exposure measurements are relatively scarce.

Eickhoff and Hunter (3) report "speed-up factors," F, of 5 to 40 (averaging 20) in accelerated fading of different paint formulations. This speed-up factor is simply the number of hours (24 hr per day basis) of outdoor exposure required to obtain the same degree of color change after 1 hr of accelerated exposure. Beck (2) reports an average factor of 20 for a large number of different finishes.

Experimental Details

This study was undertaken to obtain lightfastness correlation data on a variety of pigment colors of markedly different chemical constitution dispersed in a single vehicle system at a constant pigment volume concentration of 15 per cent. The vehicle was a good quality, air drying, medium length, soya bean oil modified alkyd.[2] Most of the pigments were exposed in full mass-tone and at two tint levels, a deep and light tint. Chalk-resistant rutile titanium dioxide was used as the tinting white with the pigment volume concentration being held constant at 15 per cent.

The finishes were sprayed to complete hiding on primed aluminum panels and exposed at an angle of 45 deg facing south in both Florida and Delaware, in an Atlas Fade-Ometer type FDA-R and a National Carbon X-1-A Accelerated Weathering Unit. The ambient temperature control on the Fade-Ometer was set at 120 F. In the Accelerated Weathering Unit (AWU), panels were exposed to direct water spray (filtered

WILLARD F. SPENGEMAN received his B.S. in Chemistry from University of Wisconsin in 1930, his M.S. in Chemistry from Purdue University in 1931, and his Ph.D. in Chemistry from University of Wisconsin in 1935. He was employed by Kimberly Clark Corp. as Research Chemist from 1935 to 1937. Since then he has been with the duPont Company in the Pigments Department-Research Department and Technical Sales. His present assignment is Laboratory Director, Technical Service Laboratory, Chestnut Run, Wilmington, Del.

GEORGE WORMALD received his degree of Bachelor of Science in Chemical Engineering in 1948 from Newark College of Engineering. He was employed by the Pigments Department of the duPont Company in 1936 in their Research Laboratory at Newark, N. J. In April, 1958, he was transferred to the Technical Service Laboratory at Chestnut Run, Wilmington, Del. as Manager of the Industrial and Automotive Finishes Section of the Pigments Department.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Syntex 62 (Jones-Dabney) 50 per cent nonvolatile, 50 per cent thinner.

city water) for 9 min out of each hour of exposure; ambient temperature was not controlled.

Periodic visual readings were made of the polished exposed finishes using unexposed control color chips for comparison. Degrees of color change were quantitatively assessed on the following arbitrary scale of 10 to zero:

Visual Rating	Relative Degree of Change
10	None
8	Slight
6	Considerable
4	Severe
2	Very severe
0	Complete failure

These subjective readings are perhaps better understood by relating them to some very approximate NBS color equivalents as shown in Table I. The precision of these subjective readings for an experienced color reader is $\pm\frac{1}{2}$ unit for color changes of 6 or less; the precision for color changes greater than 6 approaches ± 1 unit.

TABLE I.—UNIT EQUIVALENTS OF COLOR DIFFERENCE.

Visual	Approximate NBS Color Equivalents
10.0	0 to ½
9.5	½ to ½
9.0	½ to ¾
8.5	¾ to 1½
8.0	1½ to 2½
7.5	2½ to 4
7.0	4 to 6
6.0	6 to 10

Included in this study were some 45 different colored pigments representing the following chemical types:

Chrome yellows and oranges
Molybdate oranges
Chrome greens
Iron blue
Pigment green B
Phthalocyanine blues and greens
Azo yellows and reds
Vat dye pigments

Some of these pigment types, like the phthalocyanines, showed essentially no color change in the exposure periods studied, while others, like the gamut of chrome yellows and oranges, showed a considerable similarity in lightfastness characteristics. Accordingly, the graphical presentations of data are confined to 15 pigments, enough to illustrate some of the important concepts of accelerated lightfastness testing.

Results

Figures 1 to 13 show plots of degree of color change *versus* time of exposure. Three exposure time scales are shown: for exterior Florida, for Fade-Ometer, and for Accelerated Weathering Unit (AWU).

For simplicity, the Delaware exposure data were not plotted. In general, the results obtained from the Delaware exposures were in qualitative agreement with those from the corresponding Florida exposures; as would be expected, however, color changes in Florida proceeded at a faster rate. There are several exceptions to this observation such as the darker manganese-BON reds, where mass-tone darkening occurred somewhat more rapidly in Delaware than in Florida. These exceptions, however, may be related to differences in chemical nature of atmospheric impurities rather than to

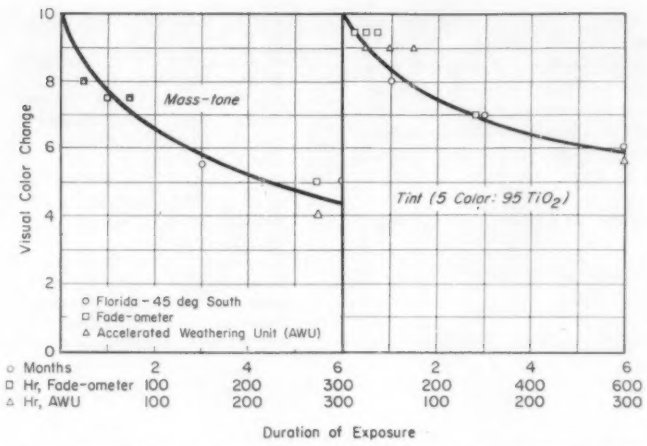

Visual Color Change
Mass-tone
Tint (5 Color: 95 TiO_2)
○ Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
○ Months 2 4 6 2 4 6
□ Hr, Fade-ometer 100 200 300 200 400 600
△ Hr, AWU 100 200 300 100 200 300
Duration of Exposure

Fig. 1.—Color retention for medium chrome yellow, exterior *versus* accelerated exposure

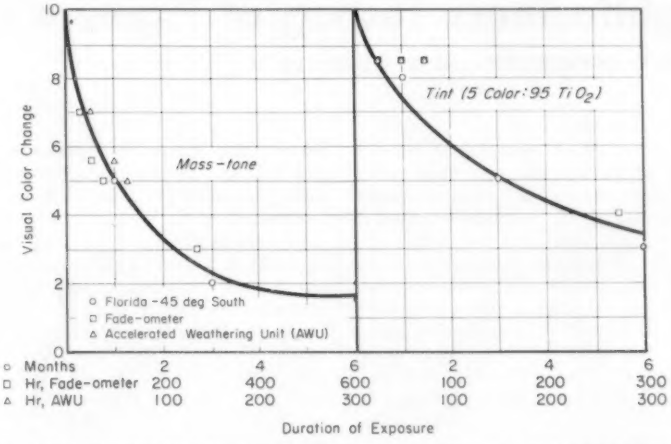

Visual Color Change
Mass-tone
Tint (5 Color: 95 TiO_2)
○ Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
○ Months 2 4 6 2 4 6
□ Hr, Fade-ometer 200 400 600 100 200 300
△ Hr, AWU 100 200 300 100 200 300
Duration of Exposure

Fig. 2.—Color retention for primrose chrome yellow, exterior *versus* accelerated exposure.

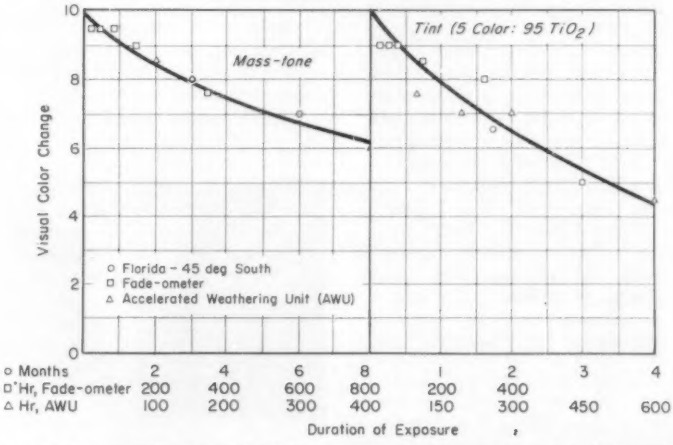

Visual Color Change
Mass-tone
Tint (5 Color: 95 TiO_2)
○ Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
○ Months 2 4 6 8 1 2 3 4
□ Hr, Fade-ometer 200 400 600 800 200 400
△ Hr, AWU 100 200 300 400 150 300 450 600
Duration of Exposure

Fig. 3.—Color retention for molybdate orange, exterior *versus* accelerated exposure.

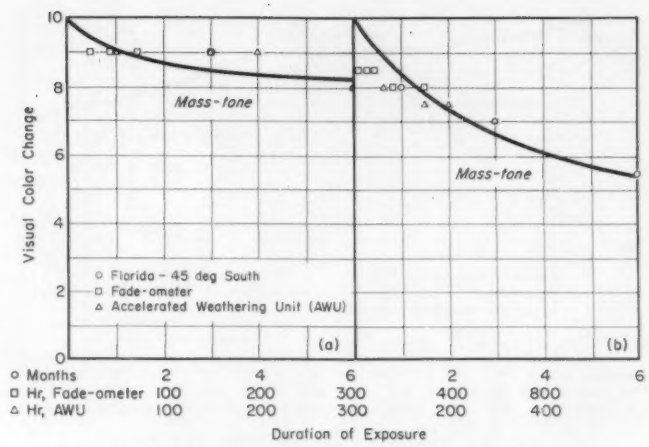
differences in intensity of ultraviolet radiation.

Lead Chromate Pigments

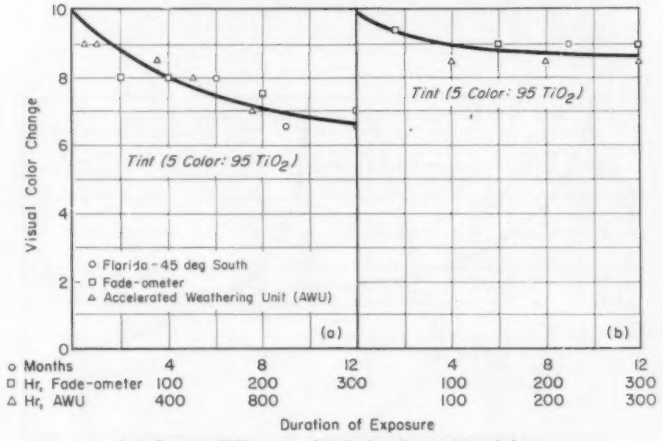
Figure 1 shows the color change-by-darkening curves for a medium shade of chrome yellow in both mass-tone and a light tint. Recalling that the precision of the visual ratings for color change is no better than $\pm\frac{1}{2}$ unit, data for the three exposures are in remarkably close agreement. This indicates good correlation and suggests that a high degree of reliance can be placed on data from either accelerated device. Comparison of the exposure time scales shows a mass-tone speed-up factor, F, of 14 for both instruments, and F values for tint of 7 and 14 for the Fade-Ometer and AWU, respectively (see Table II). It is of interest to note that the rate and degree of color change are greater in mass-tone than in tint. This is a relatively unusual lightfastness characteristic among colored pigments.

Figure 2 shows similar curves for a less lightfast chrome yellow, namely, primrose yellow. Here too, correlation is good. In this case, the mass-tone F is 7 for the Fade-Ometer and 14 for the AWU; the tint F is 14 for both units. The relatively superior lightfastness of the primrose yellow tint is also apparent.

Figure 3 illustrates the lightfastness performance of molybdate orange in mass-tone and tint under the three exposure conditions. Mass-tone F values of 7 (Fade-Ometer) and 14 (AWU) are comparable to those for chrome yellows. Tint F values of 4 and 7, however, indicate a considerably lower rate of accelerated fading. Correlation, particularly in mass-tone, is very good.



(*a*) **Iron blue (milori type).** (*b*) **Chrome green.**
Fig. 4.—Color retention, exterior *versus* accelerated exposure.



(*a*) **Orange RK.** (*b*) **Indanthrone blue lake.**
Fig. 5.—Color retention, exterior *versus* accelerated exposure.

TABLE II.—COMPARISON OF SPEED-UP FACTORS FOR VARIOUS PIGMENTS.

Pigment	Chemical Type	Color Index		Speed-Up Factor, F				Tint Ratio, Color: Titanium Dioxide	Figure Reference
				Mass-tone		Tint			
		Part I	Part II	Fade-Ometer	AWU	Fade-Ometer	AWU		
Chrome yellow, medium	$PbCrO_4$, Monoclinic	Pigment yellow 34	77600	14	14	7	14	5:95	1
Chrome yellow, primrose	$PbCrO_4/PbSO_4$, rhombic (mixed crystal)	Pigment yellow 34	77603	7	14	14	14	5:95	2
Molybdate orange	$PbCrO_4/PbMoO_4/PbSO_4$ (mixed crystal)	Pigment red 104	77605	7	14	4	7	5:95	3
Iron blue	$NH_4Fe\,[Fe(CN)_6]\cdot H_2O$	Pigment blue 27	77520	14	14	..	..	...	4
Chrome green	Mixture of iron blue and chrome yellow	Pigment green 15	...	4	7	..	..	...	4
Orange RK	Dibromoanthanthrone	Vat orange 3	59300	..	..	29	7	5:95	5
Indanthrone blue	Monochloroindanthrone	Pigment blue 22	69810	..	..	29	29	5:95	5
Green-Gold	Nickel azo complex[a]	Pigment green 10	12775	58	29	14	4	10:90	6
Pigment green B	Ferrous complex of α-nitroso-β-naphthol	Pigment green 8	10006	..	..	14	4	33:67	7
Pigment green B	Ferrous complex of α-nitroso-β-naphthol	Pigment green 8	10006	..	..	29	5	10:90	7
Toluidine red	*m*-nitro-*p*-toluidine → naphthol	Pigment red 3	12120	36	9	7	2	33:67	8
Parachlor red	*p*-chlor-*o*-nitranaline → β-naphthol	Pigment red 6	12090	14	14	14	3	10:90	9
Lithol rubine	*p*-toluidine-*m*-sulfonic acid → β-hydroxy-naphthoic acid (Ca salt)	Pigment red 57	15850	29	4	4	7	33:67	10
BON red	*o*-chloro-*p*-toluidine-*m*-sulfonic acid → β-hydroxynaphthoic acid (Mn salt)	Pigment red 48	15865	58	29	14	14	10:90	11
Hansa yellow G	*m*-nitro-*p*-toluidine → acetoacetanilide	Pigment yellow 1	11680	7	7	14	4	5:95	12
Benzidine yellow OT	3-3′ dichlorobenzidine → $(acetoacet\text{-}o\text{-}toluidide)_2$	Pigment yellow 14	21095	29	7	7	2	5:95	13

[a] US Patent 2,396,327.

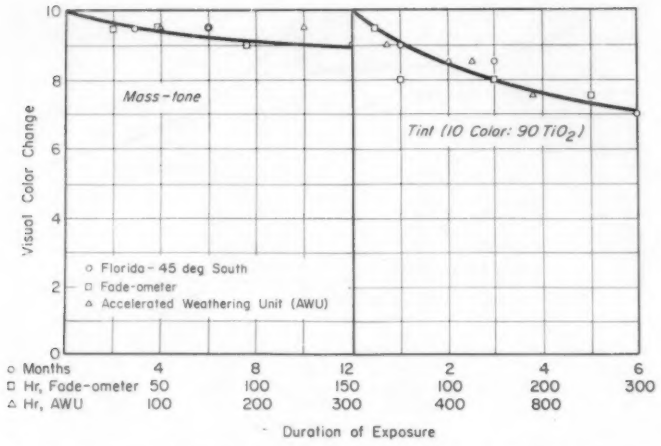

Mass-tone
Tint (10 Color: 90 TiO2)
Visual Color Change
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 4 8 12 2 4 6
□ Hr, Fade-ometer 50 100 150 100 200 300
△ Hr, AWU 100 200 300 400 800
Duration of Exposure

Fig. 6.—Color retention for Green-Gold (US Patent 2,396,327), exterior *versus* accelerated exposure.

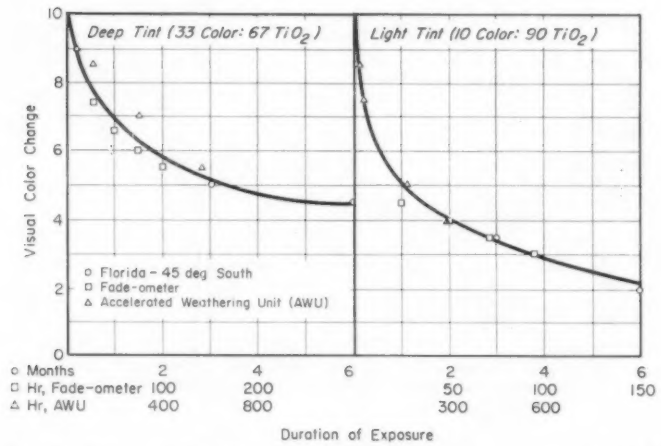

Deep Tint (33 Color: 67 TiO2)
Light Tint (10 Color: 90 TiO2)
Visual Color Change
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 2 4 6 2 4 6
□ Hr, Fade-ometer 100 200 50 100 150
△ Hr, AWU 400 800 300 600
Duration of Exposure

Fig. 7.—Color retention for pigment green B, exterior *versus* accelerated exposure.

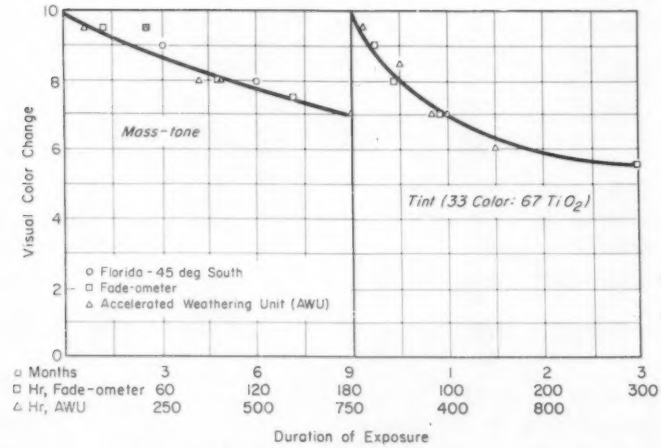

Mass-tone
Tint (33 Color: 67 TiO2)
Visual Color Change
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 3 6 9 1 2 3
□ Hr, Fade-ometer 60 120 180 100 200 300
△ Hr, AWU 250 500 750 400 800
Duration of Exposure

Fig. 8.—Color retention for toluidine red, exterior *versus* accelerated exposure.

Although not a part of this study, it has been observed that the apparent lightfastness of molybdate orange is significantly better when dispersed in an oxidizing vehicle (for example, linseed oil) than it is in a vehicle of lower oxidizing potential (for example, long oil soya alkyd). Conversely, parachlor red (an azo pigment dyestuff (Fig. 9)) shows superior tint lightfastness in the alkyd system. This emphasizes the highly specific character of lightfastness testing and the danger of indiscriminate comparisons.

Iron Blues and Chrome Greens

Figure 4 shows masstone color retention curves for iron blue and chrome green (mixture of iron blue and chrome yellow). Both units provide an F value of 14 for the iron blue. For this particular light shade of chrome green, however, the Fade-Ometer and AWU factors are 4 and 7, respectively. These values are more in line with those for chrome yellow, a major component of chrome green. An additional similarity may be seen in the wider scattering of points for short-term exposure (less than two months) of the chrome green (Fig. 4) and the chrome yellow tints (Figs. 1 and 2).

Vat Dye Pigments

Figure 5 shows the exposure performance in tints of two relatively lightfast vat dye pigments, orange RK and indanthrone blue. Of the two, indanthrone blue is obviously the more lightfast. A speed-up factor, F, of 29 is realized for indanthrone blue in both units, whereas, for orange RK, the Fade-Ometer F value is 29 and the AWU F value is 7. Correlation for both pigments is very good.

Green-Gold[3]

As is evident in Fig. 6, Green-Gold (a nickel azo complex) is very lightfast. Both accelerated units provide high masstone F values (58 Fade-Ometer and 29 AWU). Tint fading in the Fade-Ometer is accelerated at a satisfactory rate ($F=14$), but not so in the AWU ($F=4$). Lack of appreciation of this difference in F values would lead to widely different opinions of the tint lightfastness of this pigment from dry and wet accelerated exposures. Despite the differences in speed-up factors, correlation with exterior exposure is good.

Pigment Green B

Pigment green B is not used in masstone and, as may be seen from Fig. 7, is not particularly lightfast in either deep or light tints. It is not generally used in exterior finishes. Nevertheless, the accelerated exposure data are in excellent agreement with those for exterior ex-

[3] US Patent 2,396,327.

posure. As in the case of the Green-Gold tint previously discussed, dry accelerated exposure (that is, Fade-Ometer) produces much more rapid fading at both tint levels ($F = 14$ and 29 for deep and light tints, respectively) than does wet accelerated exposure ($F = 4$ and 5).

Red Azo Pigments

Toluidine red is well known for its high order of masstone lightfastness but relatively poor resistance to fading in tints. This reputation is confirmed in Fig. 8. Correlation of exposure data is, once again, very good, but here too, the Fade-Ometer provides a considerably higher rate of accelerated color change ($F = 36$ mass-tone, and 7 tint) than was realized in the AWU ($F = 9$ mass-tone, and 2 tint).

Figure 9 demonstrates that the mass-tone lightfastness of parachlor red is superior even to that of toluidine red, previously shown. Considering the very slight color change (less than $\frac{3}{4}$ NBS unit) in mass-tone after nine months exterior exposure and the $\frac{1}{2}$-unit precision of the visual ratings, correlation is excellent. Equal mass-tone F values of 14 were obtained in both instruments. In tint, however, the wet exposure offered little acceleration ($F = 3$) as compared to dry exposure ($F = 14$).

Lithol rubine is a brilliant precipitated azo pigment of relatively poor lightfastness as dramatically demonstrated in Fig. 10. This pigment finds wide application in blends with molybdate orange (Fig. 3) in formulating low-cost red industrial finishes. Rather typical of the more fugitive colors, correlation of the exposure data is excellent. The Fade-Ometer provides the greater accelerated color change in mass-tone ($F = 29$ *versus* $F = 4$, AWU) but the reverse is true in tints ($F = 4$ *versus* $F = 7$, AWU).

Oddly enough, although correlation for both units was good for molybdate orange and lithol rubine when tested separately, Fade-Ometer exposures of blends of these pigments (as mass-tones) were found not to agree at all with outdoor and AWU exposures. In the Fade-Ometer, the blends darkened but showed no significant fading of the lithol rubine. Exterior and AWU exposures, however, showed rapid fading of the red component.

BON red (precipitated with manganese) is another azo red possessing good mass-tone color retention. Good correlation of mass-tone and tint lightfastness data are shown in Fig. 11. High mass-tone speed-up factors, F, of 58 for the Fade-Ometer and 29 for the AWU were obtained; lower tint F values of 14 for both units were realized.

Yellow Azo Pigments

Hansa yellow G, or toluidine yellow,

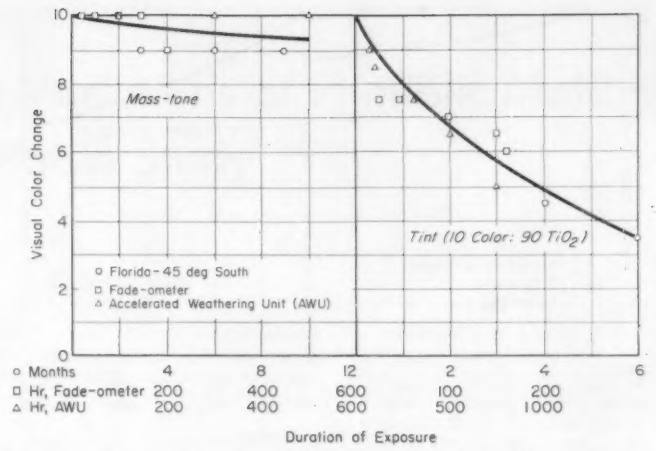

Visual Color Change
Mass-tone
Tint (10 Color: 90 TiO2)
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 4 8 12 2 4 6
□ Hr, Fade-ometer 200 400 600 100 200
△ Hr, AWU 200 400 600 500 1000
Duration of Exposure

Fig. 9.—Color retention for parachlor red, exterior *versus* accelerated exposure.

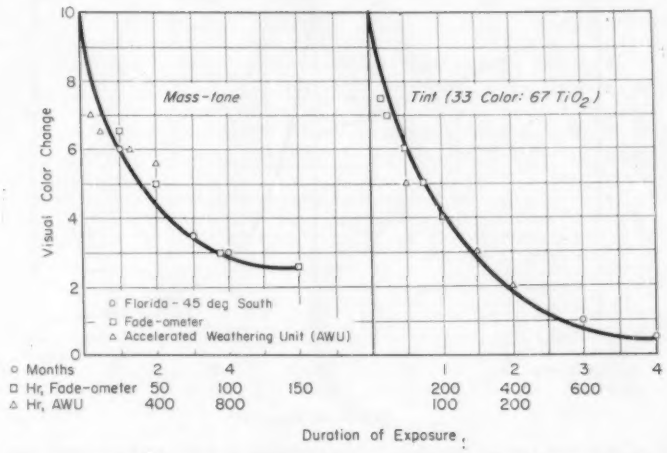

Visual Color Change
Mass-tone
Tint (33 Color: 67 TiO2)
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 2 4 1 2 3 4
□ Hr, Fade-ometer 50 100 150 200 400 600
△ Hr, AWU 400 800 100 200
Duration of Exposure

Fig. 10.—Color retention for lithol rubine (resinated), exterior *versus* accelerated exposure.

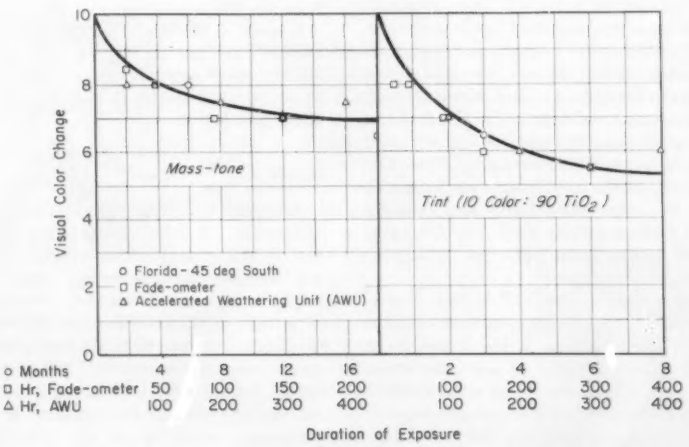

Visual Color Change
Mass-tone
Tint (10 Color: 90 TiO2)
o Florida - 45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 4 8 12 16 2 4 6 8
□ Hr, Fade-ometer 50 100 150 200 100 200 300 400
△ Hr, AWU 100 200 300 400 100 200 300 400
Duration of Exposure

Fig. 11.—Color retention for permanent red 2B-manganese salt (B.O.N. red), exterior *versus* accelerated exposure.

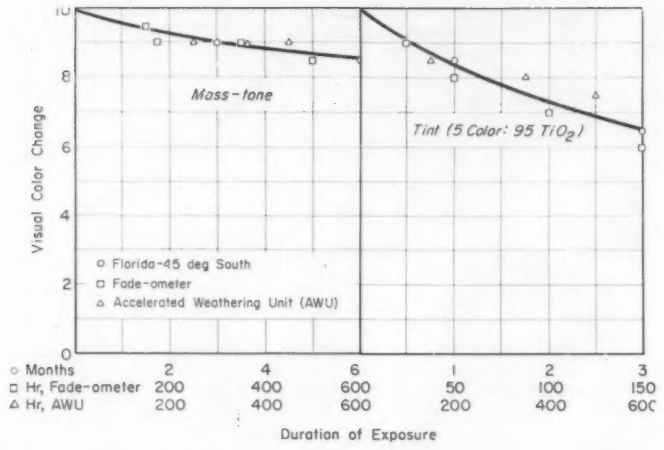

Visual Color Change
Mass-tone
Tint (5 Color: 95 TiO_2)
o Florida-45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 2 4 6 1 2 3
□ Hr, Fade-ometer 200 400 600 50 100 150
△ Hr, AWU 200 400 600 200 400 600
Duration of Exposure

Fig. 12.—Color retention for Hansa yellow G, exterior *versus* accelerated exposure.

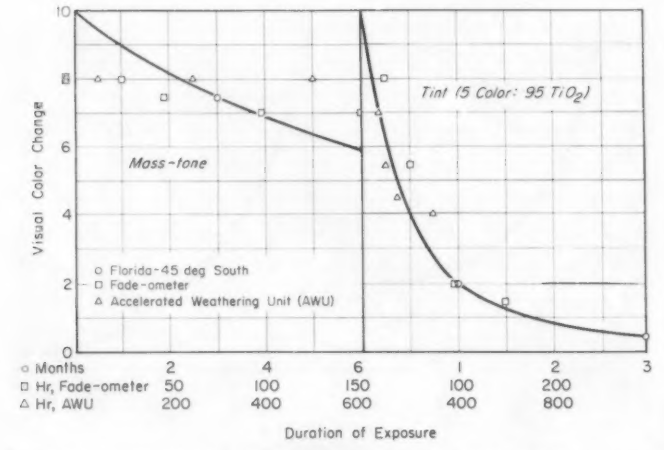

Visual Color Change
Tint (5 Color: 95 TiO_2)
Mass-tone
o Florida-45 deg South
□ Fade-ometer
△ Accelerated Weathering Unit (AWU)
o Months 2 4 6 1 2 3
□ Hr, Fade-ometer 50 100 150 100 200
△ Hr, AWU 200 400 600 400 800
Duration of Exposure

Fig. 13.—Color retention for benzidine yellow (*o*-toluidide type), exterior *versus* accelerated exposure.

is represented in Fig. 12, where its excellent mass-tone lightfastness is apparent. Correlation of both accelerated exposures with exterior exposure leaves little to be desired. A moderately high mass-tone F value of 7 in both units and a tint F value of 14 in the Fade-Ometer offer good acceleration rates. The tint F value in the AWU, however, is only 4. In this respect toluidine yellow behaves in a fashion similar to Green-Gold, pigment green B, toluidine red, and parachlor red.

Benzidine yellow OT is not a particularly lightfast pigment but receives some consideration in the formulation of lead-free paints. As may be seen in Fig. 13, correlation of mass-tone AWU data with exterior exposure data is poor; correlation is only fair for the Fade-Ometer. In tints, correlation for both devices is good. Although not very reliable, the mass-tone F value for the AWU is 7 while that for the Fade-Ometer is 29. In tints, the Fade-Ometer once again offers a higher rate of accelerated fading ($F=7$) than does the AWU ($F=2$).

Discussion

Although this study was by no means exhaustive, it does appear that accelerated fading devices can provide rapid and reliable color-retention data for colored pigmented surface coatings. It is equally apparent, however, that the full potential value of these instruments can be realized only when supported by an adequate background of correlating data for the systems to be evaluated.

In view of the wide variation in F values obtained (ranging from 2 to 58) for the pigments tested, as well as the highly specific performance characteristics of each pigment in these instruments, there appears to be no justification for assigning an average F value to either device. Further, for general testing of water-resistant samples, there appears to be no justification to claim an advantage for either wet or dry accelerated exposures. On the basis of limited data, more rapid fading of tints of colored organic pigments seems to favor the use of a Fade-Ometer. This may be the result of the higher concentration of ultraviolet radiation from the Fade-Ometer light source. The manufacturers indicate 20 per cent below 400 mμ for the Fade-Ometer and 12 per cent for the X-1-A Accelerated Weathering Unit. Haynes (4) reports 4 per cent of solar radiation as received on the surface of the earth is in the range of 200 to 380 mμ.

Conclusions

1. The relative colorfastness of pigments of the same chemical nature can be reliably compared in both wet and dry accelerated exposure devices (Fade-Ometer and AWU).

2. The approximate colorfastness on exterior exposure of a pigment, or the relative colorfastness of two or more pigments which differ in chemical nature, cannot usually be reliably predicted from accelerated exposures, except when correlation has been previously developed and corresponding speed-up factors applied. Unless modified, however, the accelerated devices cannot duplicate the influence of abnormal atmospheric conditions (for example, chemical impurities).

Acknowledgment:

The authors wish to express their appreciation to J. T. Goolkasian and J. A. Lamiet for assistance in the experimental work.

References

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(2) S. E. Beck, "Protective and Decorative Coatings," (J. J. Mattiello, editor), John Wiley and Sons, Inc., New York, N. Y., Vol. V, Chapter 3, p. 315, (1946).

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(4) B. C. Haynes, "Fundamentals of Atmospheric Elements," Symposium on Conditioning and Weathering, Am. Soc. Testing Mats., p. 3 (1952). (Issued as separate publication *STP No. 133.*)

Flexural and Impact Variations of Phenolic Moldings: A Statistical Round-Robin Study

By C. ELMER and E. C. HARRINGTON, Jr.

FLEXURAL strength and impact strength have long been standard methods for determining the mechanical behavior of plastic materials. Procedures for each of these tests have been a part of ASTM standards[1,2] for many years. It has also been obvious, however, that the method of specimen preparation, which not only varies between but within specific plastic materials, may play a prominent part in determining test results.

In an effort to standardize on specific methods of specimen preparation, a round robin was undertaken by Subcommittee IX on Molds and Molding of ASTM Committee D-20 on Plastics to compare compression *versus* transfer-molded specimens and to establish molding procedures for each. The proposed program involved such a large number of potentially significant variables that a fairly complex statistical design was necessary to accomplish the desired end.

It was decided to work only with flexural and impact test results, while obtaining two sets of the latter in order to determine the difference in testing the gate end and dead end of a transfer-molded bar.

For transfer-molded specimens, the difference between two molding laboratories had to be established.

For compression-molded specimens, not only were four molding laboratories to be compared, but two methods of specimen preparation—preheated pills *versus* cold powder—were to be evaluated.

In comparing transfer-molded with compression-molded specimens, both the difference in level and the test error (reproducibility) were to be obtained.

A study of the effect of three molding temperature levels on property level and test precision was planned.

The seven phenolic molding materials were chosen for their dissimilarity so as to be able to judge differences in reproducibility as well as level by various tests.

Six testing laboratories were to be evaluated for differences in test level and reproducibility.

From the point of view of thoroughness and simplicity, it would have been desirable to design the round-robin program following ASTM Recommended Practice for Interlaboratory Testing of Textile Materials (D 990).[3] This design is a split plot factorial, and has been the basis of numerous round robins, including those of Committee D-20 (Table I). In the current problem, this very ideal design would have involved a prohibitive amount of work. With seven materials, two types of molding, six molding laboratories, two conditions of preheat, three molding temperatures, and six testing laboratories, the usual factorial would have required 3024 combinations of testing conditions. If seven pieces were broken under each combination (in order to measure test reproducibility), the data would have consisted of 21,168 observations for each property, and there were four properties to be measured!

Some reduction in the size of the experiment was dictated by the fact that not all molding laboratories were prepared to mold under the conditions of

TABLE I.—TABULAR FORM FOR DATA.

	Laboratory 1						Laboratory 2 or More					
	Operator 1			Operator 2 or More			Operator 1			Operator 2 or More		
	Test 1	Test 2	Or More	Test 1	Test 2	Or More	Test 1	Test 2	Or More	Test 1	Test 2	Or More
Material A:												
Sample 1	...	...	...	...	...	...	...	...	...	...	...	...
Sample 2	...	...	...	...	...	...	...	...	...	...	...	...
Sample 3	...	...	...	...	...	...	...	...	...	...	...	...
Or more	...	...	...	...	...	...	...	...	...	...	...	...
Material B:												
Sample 1	...	...	...	...	...	...	...	...	...	...	...	...
Sample 2	...	...	...	...	...	...	...	...	...	...	...	...
Sample 3	...	...	...	...	...	...	...	...	...	...	...	...
Or more	...	...	...	...	...	...	...	...	...	...	...	...
Material C:												
Or more	...	...	...	...	...	...	...	...	...	...	...	...

CURTIS ELMER, until recently, has been Research Group Leader at Monsanto Chemical Company's Plastics Division in Springfield, Mass. His activities have included test and product development of phenolic and melamine resins for a variety of industrial applications. His present position as Manager of Technical Service involves the directing of field and laboratory customer service activities in surface coating, textile, paper and industrial resins applications.

EDWIN C. HARRINGTON, JR. has been concerned with the application of industrial statistics to research and production for fourteen of the last twenty-two years with the Plastics Division of Monsanto Chemical Co. As Manager of Industrial Statistics he was responsible for developing procedures for quality control in production; and currently, as Scientist, for the use of experimental statistics in the research department.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] 1958 Book of ASTM Standards, ASTM Tentative Method of Test for Flexural Properties of Plastics, Part 9, p. 255.
[2] *Ibid.*, ASTM Methods of Test for Impact Resistance of Plastics and Electrical Insulating Materials, Part 9, p. 284.
[3] *Ibid.*, ASTM Recommended Practice for Interlaboratory Testing of Textile Materials, Part 10, p. 367.

transfer and compression prescribed, and that the variable identified as preconditioning applied only to the compression-molded specimens. Whether we wished it or not, these restrictions reduced the size of the experiment to 648 testing conditions, or a mere 4536 observations for each property and, of course, introduced an unbalance into the experimental design which would preclude the possibility of a straightforward analysis of variance as outlined in ASTM Method D 990.

When less than a full factorial experiment is run, some confounding always takes place. By confounding is meant an entangling of effects such as would result if, for example, Bell Telephone Laboratories molded all the transfer specimens and General Electric Co. molded all the compression specimens. In this case, any difference between the transfer and compression molding might also be due to a difference between Bell and G.E. In this investigation it was possible to assign at least two laboratories to each molding condition, and thus to reduce the confounding to a minimum.

The experiment was still unreasonably large. We could reduce it further by removing some of the variables we had hoped to evaluate, or possibly by another device of statistics, fractional replication. Through some foresight in the earlier stages of planning, it developed that there were three main blocks of molding types, in each of which there were six testing laboratories, six molding conditions (two laboratories at three temperatures each), and six materials. This foreordained circumstance allowed a one-sixth replicate of the full factorial which reduced the testing in each block by 83 per cent, resulting in a final round robin of 108 testing conditions as compared with the original 3024. It is interesting to note that this is $3\frac{1}{2}$ per cent of the initial full factorial experiment. (See Table II.)

Because of the importance of reporting all data accurately and completely (especially in a reduced experiment such as this) detailed instructions and data sheets were provided for all the participants (Table III). The completed data sheets allowed a relatively easy transfer to a digital code for use with an electronic computer. Each combination was represented by a six-digit number describing its elements. For example: 323114 indicated material C, compression-molded by Bell Laboratories using preheat condition prior to molding at 290 F, and subsequently tested at Picatinny Arsenal (test cell C7, Table II). An IBM card carrying this number was then used to transmit all the experimental data obtained on the above combination, after transforming them to natural logarithms. (In the analysis of the data, it was necessary to use natural logarithms, rather than the original arithmetic scale, because the testing error is proportional to the value being considered. After statistical analysis, these logarithms were re-transformed to the more familiar arithmetic scale.)

The data reported by the testing laboratories were analyzed in two ways: (1) to determine the average levels between the tested properties as influenced by the experimental variables, for example, the average gate-end impact *versus* the dead-end impact, and (2) to determine the variance (or test precision) within the several testing combinations. The first analysis followed the usual pattern of the analysis of variance, modified as necessary by the experimental design. For the second (that is, test precision), the variance of the seven observations was calculated for the 108 testing combinations and then an analysis of variance conducted on these variances. All calculations were conducted on an IBM 704 computer.

TABLE II.—EXPERIMENTAL DESIGN FOR ASTM ROUND ROBIN ON PHENOLIC MOLDINGS.[a]

	Transfer Molding by[c]						Compression Molding by[d]											
							Preheated[b]						Cold Powder					
	Durez			Monsanto			Bell			Bakelite			Western Electric			General Electric		
Molding Temperature	290 F	320 F	340 F	290 F	320 F	340 F	290 F	320 F	340 F	290 F	320 F	340 F	290 F	320 F	340 F	290 F	320 F	340 F
Testing laboratories:																		
Durez	E1	P2	B3	D4	C5	A6	Q7	A8	C9	E10	D11	P12	D13	E14	A15	C16	P17	Q18
General Electric	C1	D2	P3	B4	A5	E6	A7	P8	D9	Q10	E11	C12	Q13	A14	C15	E16	D17	P18
Bakelite	D1	E2	A3	C4	B5	P6	E7	Q8	P9	D10	C11	A12	A13	P14	D15	Q16	E17	C18
Picatinny	B1	C2	E3	A4	P5	D6	C7	D8	Q9	P10	A11	E12	E13	Q14	P15	D16	C17	A18
Western Electric	A1	B2	D3	P4	E5	C6	P7	C8	E9	A10	Q11	D12	C13	D14	Q15	P16	A17	E18
Monsanto	P1	A2	C3	E4	D5	B6	D7	E8	A9	C10	P11	Q12	P13	C14	E15	A16	Q17	D18

[a] ASTM procedures followed: Specification for Phenolic Molding Compounds (D 700 – 57 T); Recommended Practice for Molding Test Specimens of Phenolic Materials (D 796–51); Specification for Molds for Test Specimens of Plastic Molding Materials (D 647 – 54 T); Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (D 618–58).
[b] Preheat conditions: 220 to 240 F; 20 to 30 sec for general-purpose materials, 45 ± 10 sec for mica-filled (material B).
[c] Transfer mold pressure, minimum to fill plus 1000 psi to ram; 2-min cure.
[d] Compression molding pressure, 2500 ± 500 psi; 2-min cure (preheated), 5-min cure (cold powder).

TABLE III.—DATA SHEET, ASTM ROUND ROBIN.

These data for cell number (See page 2 of Round Robin Instructions) _____

		A B C D E P Q	IBM Code*
1.	Material (circle code letter)		
2.	Transfer or Compression Molded		
3.	Molding Laboratory		
4.	Preheat or Cold Powder		
5.	Molding Temperature		
6.	Testing Laboratory		
7.	Date of Molding		
8.	Date of Testing		
9.	Type of Testing Machine		
10.			
11.			
12.			

TEST RESULTS

Transfer	Tensile	½ by ½ Flexural	½ by ½ Flexural	½ by ½ Impact (Gate End)	½ by ½ Impact (Dead End)	½ by ½ Impact (Compression)
	omit	omit	x	x	x	omit
Compression	omit	omit	x	omit	omit	x
Test No. 1						
Test No. 2						
Test No. 3						
Test No. 4						
Test No. 5						
Test No. 6						
Test No. 7						

*Do not use this column.
NOTE.—Use one data sheet for each cell in the round-robin design. Return all sheets to C. Elmer, Monsanto Chemical Co., Springfield 2, Mass., when data are complete. Contact C. Elmer if any questions arise.

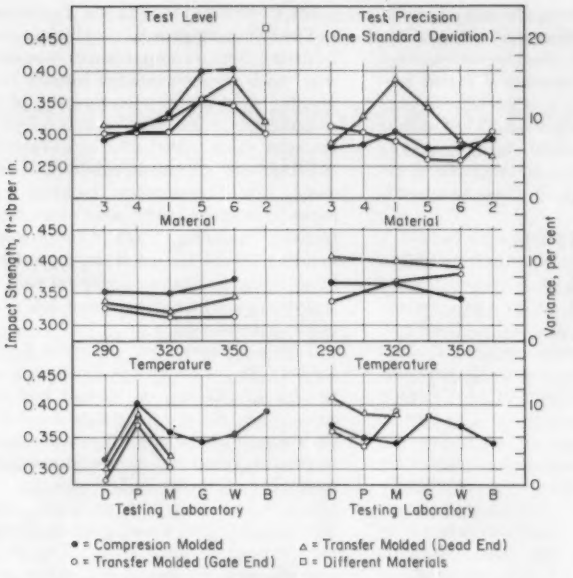

Fig. 1.—Analysis of level and analysis of variance on impact strength data.

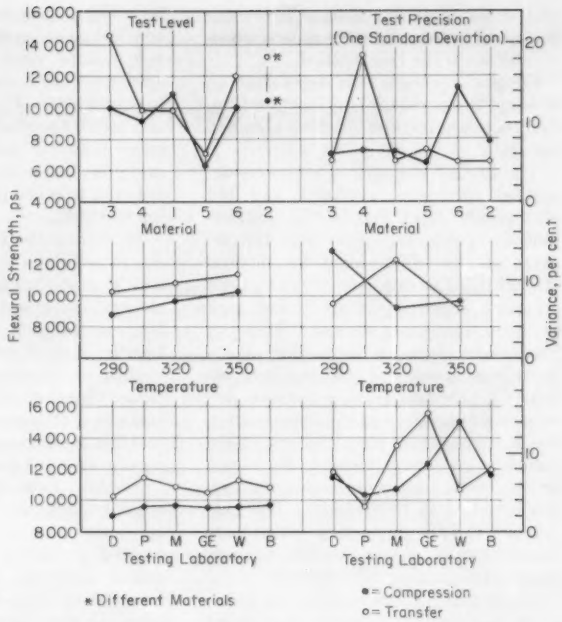

Fig. 2.—Analysis of level and analysis of variance on flexural strength data.

TABLE IV.—ASTM ROUND ROBIN, ANALYSIS OF VARIANCE, IMPACT STRENGTH.

	Test Values, per cent	Variances, (Duplicate Error or Precision), per cent
Materials:		
Compression	99.9	...
Transfer, gate end	99	...
Transfer, dead end	...	...
Molding methods:		
Compression molding		
Preheat versus cold powder	...	...
Molding laboratories	95	...
Transfer molding		
Gate end *versus* dead end	99	...
Molding laboratories	...	...
Compression *versus* transfer	>95[a]	>95[a]
Molding temperatures		
Compression	...	95
Gate end	...	95
Dead end	...	...
Testing laboratories:		
Compression	99	95
Transfer		
Dead end	99	...
Gate end	99.99	99

[a] Confidence level not calculated, but estimated greater than 95 per cent.

TABLE V.—ASTM ROUND ROBIN, ANALYSIS OF VARIANCE, FLEXURAL STRENGTH.

	Confidence Level Test Values, per cent	Variances, (Duplicate Error or Precision), per cent
Materials:		
Compression	99.99	...
Transfer	99.99	95
Molding methods:		
Compression molding		
Preheat *versus* cold powder	...	...
Molding laboratories	99	...
Transfer molding		
Molding laboratories	...	...
Compression *versus* transfer	>99[a]	?
Molding temperatures		
Compression	99.9	...
Transfer	99.9	...
Testing laboratories:		
Compression	...	...
Transfer	95	...

[a] Confidence level not calculated, but estimated greater than 99 per cent.

Analysis of Data

The data taken under the wide variety of conditions and by the six testing laboratories were compiled and analyzed by the analysis of variance technique, with results as shown in Tables IV and V. The critical significance level was chosen at 0.05, or the equivalent confidence level of at least 95 per cent that the effect noted does, in fact, exist. Those effects which did not achieve this level of significance are indicated in these tables with dots.

The statistically significant effects are described in Figs. 1 and 2. It should be noted that the "average" values which are plotted are the geometric means rather than arithmetic means, because the analysis was conducted on the logarithms of the data. Test precision, for the same reason, is expressed as a percentage of these average values.

Results and Conclusions

General Conclusions

This round robin has provided useful information concerning the effects of the several variables considered, even though rather large inconsistencies apparently exist among the testing techniques and equipment of the several laboratories involved.

The flexural strength of transfer-molded specimens averaged 13.1 per cent greater than that of compression-molded specimens, although this increase varied with the type of material being considered. The precision attained with both transfer and compression specimens was about 5.5 per cent, expressed

as the standard deviation. There appeared to be no difference in test precision between the two methods.

Flexural strength was dependent on molding temperature and increased linearly between 290 and 350 F by about 12 per cent.

The impact strength of compression-molded specimens averaged 10.4 per cent greater than that of the transfer-molded specimens. This was the reverse of the effect noted for flexural strength. The dead end of the transfer specimen averaged about 5 per cent stronger than the gate end. It is not possible to make an unqualified statement concerning the test precision attained by the two molding methods, because there are too many inconsistencies, but it appears that the dead end of the transfer specimen yielded the least precise data, having an average standard deviation of 10 per cent. The gate end and the compression specimen were approximately equal, giving average standard deviations of 7 per cent.

These general conclusions are based on the averages of all materials as tested in all laboratories, and they may not hold for specific materials where the conclusions are not so clear cut. Much of this indeterminacy arises from the inconsistency in both level and test precision which existed among the several testing laboratories.

Flexural Strength (See Fig. 1 and Table IV)

Materials.—The seven phenolic molding materials gave a range in level from 6000 to 14,000 psi. This, therefore, represents an adequate spread for the observation of different methods of testing and specimen preparation. Not only were the test levels found to be significantly different, but reproducibility within each set of test values was also found to be significantly different between materials in the case of transfer moldings. However, no significant difference in test precision was shown in the case of compression-molded materials.

Molding Methods:

(1) Compression.—No significant changes in level were found in comparing specimens made from preheated preforms with those prepared from cold powder. Test precision was found essentially equal in both cases.

Comparison of four molding laboratories showed an unexpectedly significant difference among them. However, no difference in precision of the results can be attributed to molding laboratory variations.

(2) Transfer. — Preparation of transfer-molded specimens by two different laboratories did not affect test levels or reproducibility.

(3) Compression Versus Transfer. —In comparing compression with transfer-molded specimens, one can generally conclude that (*a*) it is easier to reproduce test results when compression-molded specimens are prepared in different laboratories than when transfer moldings are used, and (*b*) no significant differences between flexural strength results or duplication errors can otherwise be attributed to a change in these two molding methods.

(4) Molding Temperatures. — A rise in molding temperature from 290 to 350 F was shown to increase flexural strength by about 10 per cent, regardless of molding method. However, transfer-molded specimens gave flexural results which were about 10 per cent higher than compression-molded results, regardless of temperature. Changes in molding temperature appear to have no significant effect on reproducibility.

Testing Laboratories. — A slightly greater difference in test levels between laboratories was produced with transfer-molded specimens than with compression-molded ones. A comparison of test levels again shows transfer-molded specimens to give about 10 per cent higher strength than compression moldings.

Impact Strength (See Fig. 2 and Table V)

Materials.—As was to be expected, a significant difference in impact strength was found among the seven materials chosen. The range of results (0.30 to 0.40 ft-lb)' was considered sufficient to obtain meaningful data. No significant differences in the duplication error of different materials could be established.

Molding Methods:

(1) Compression Molding.—No significant difference in test results was found when material was preheated rather than used as the cold powder. These methods also caused no significant difference in precision of the test results.

Comparison of four molding laboratories showed a significant difference (95 per cent) in test results, although no difference in test precision was detected.

(2) Transfer Molding.—In the case of transfer molding, where specimens can differ in character from one end to the other, a 99 per cent significant difference was shown between test results on gate end *versus* dead end, the latter showing consistently higher impact strength. In addition, there was a 99 per cent significant difference in duplication error within test results, the dead end generally showing poorer precision than the gate end.

(3) Molding Laboratories. — No significant difference was observed among laboratories in the case of transfer-molded specimens, indicating better laboratory-to-laboratory reproducibility. Precision, however, was significantly different (99 per cent) in the case of dead-end test; there was no difference between gate-end test specimens.

(4) Compression Versus Transfer —The following general conclusions can be drawn from a comparison of compression- with transfer-molded impact test results: (*a*) Compression molding gives consistently equal or higher impact strength than either the dead-end or gate-end side of transfer-molded specimens. (*b*) Compression molding appears to produce better sensitivity than transfer molding. (*c*) Compression molding seems to result in reproducibility equal to that of dead-end side of transfer specimens and is about half that of the gate-end side.

Testing Laboratories.—A distinct difference (99 per cent) was shown among testing laboratories on impact test results. The three data points available show identical changes for compression-molded and gate-end, dead-end transfer-molded materials. Differences in reproducibility were not so clear, with only the gate end showing up at the 99 per cent significance level. The dead end showed no significant difference, whereas compression moldings gave differences at the 95 per cent level.

In conclusion, we hope that some light has been shed on the problem of test specimen preparation and the effect on test values and duplication errors. The data, by themselves, mean nothing unless they are used for intelligent conclusions as to their value to the industry.

In utilizing the results presented here, it must be considered that the excellent agreement shown in most cases was made possible by careful adherence to instructions and specifically duplicated molding conditions. It is well known that this type of agreement is not as common, particularly with Izod impact testing. Nevertheless, it can be done, which is additional reason for work to commence in Committee D-20 on Plastics on drafting proper recommended practices for molding

Acknowledgment:

The program described in this paper was conceived in June, 1957, in order to evaluate transfer molding as a method for preparing test specimens of phenolic molding powders. Mr. E. F. Jackson, Monsanto Chemical Co., was a prime mover in getting this activity started but was forced to leave the project due to a shift in responsibilities. The following members of ASTM Committee D-20 on Plastics were responsible for the success of this project by virtue of their unselfish devotion of time and patience which is necessary in a program of this magnitude: F. Florentine, General Electric Co.; H. Gunst, Union Carbide Plastics Co.; G. D. Johnston, Durez Plastics Div.; J. M. Rausch, Bell Telephone Laboratories, Inc.; G. R. Rugger, Picatinny Arsenal; and K. A. Weston, Western Electric Co.

Moisture Penetration of Brick Masonry Panels

By T. RITCHIE and W. G. PLEWES

Large brick masonry panels of several types of bricks and two mortars were tested for moisture penetration by spraying water on one face and maintaining an air-pressure difference across the panel to simulate wind and rain. The resistance of the panels to moisture penetration varied greatly and depended on the properties of the brick and mortar in combination. Leakage occurred at the brick-mortar interface, and in some cases through the bricks. Information on the influence of air pressure on leakage and on the influence of wall thickness on leakage was obtained. Working properties of the materials affected the bricklayer's technique of constructing the panels. The effect on moisture penetration of weathering panels by outdoor exposure was also studied.

Rain penetration of brick masonry walls has been a problem with many buildings in Canada. It is most frequent in areas such as the Atlantic provinces, which have prolonged rainstorms, but it is not uncommon in interior regions. Many buildings affected by rain penetration have been examined by members of the Division of Building Research of the National Research Council, and a survey of the extensive literature dealing with the subject has been prepared (1).[1]

Laboratory studies of some of the factors contributing to the problem have been undertaken using an apparatus for determining the resistance to moisture penetration of large brickwork panels based on that developed in the National Bureau of Standards (2, 3). This paper describes the apparatus and the results of some initial tests of panels made of several types of bricks and two mortars.

Test Method

Panels about $3\frac{1}{2}$ ft wide and 4 ft high were constructed by an experienced bricklayer and allowed to cure before being used in the moisture penetration tests. The apparatus, Fig. 1, consisted of an air-pressure chamber and a wheeled frame carrying the test panel, which could be moved into position and tightly sealed in place against the chamber to form one side of it. By pumping air into the chamber an air-pressure difference was maintained across the panel to give the effect of wind blowing against the wall of a building. Water from a horizontal pipe placed near the top course of bricks was sprayed from holes spaced along its length so that small streams of water spread over the surface of the panel in a film.

Water was pumped through the flow meter to the horizontal pipe, across the face of the panel, and deflected at the base of the panel back into the water supply tank to be pumped to the panel again. Air was supplied to the

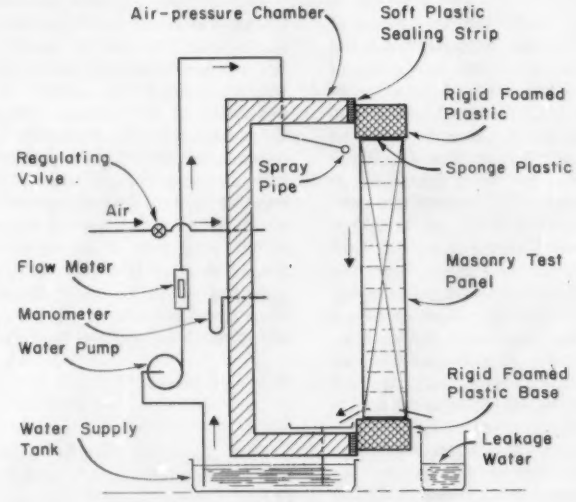

Fig. 1.—Diagram of apparatus.

T. RITCHIE is an Associate Research Officer of the Division of Building Research of the National Research Council of Canada. He graduated in ceramic engineering from the University of Toronto in 1949 and joined the Division of Building Research in 1950, where he has undertaken studies of problems relating to unit masonry construction. He is a member of ASTM Committee C-15 on Manufactured Masonry Units.

W. G. PLEWES is an Associate Research Officer of the Division of Building Research of the National Research Council of Canada. He received his B.Sc. in Civil Engineering from the University of Manitoba in 1949 and M.Appl.Sc. from Queen's University in 1954. After 3 yr with Canadian National Railways in the design of bridges and buildings and 2 yr as lecturer in civil engineering at the Royal Military College, Kingston, he joined the Division of Building Research in 1954, and has been engaged in structural research, principally in the field of concrete.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

Fig. 2.—Air-pressure chamber and wheeled frame of moisture penetration apparatus.

chamber through a regulating valve, and air pressure was measured by a manometer.

Each panel was built on a slab of rigid foamed plastic material cemented to a steel channel, with a coating of mortar trowelled on the sides and top of the panel to level these surfaces. The channel with the panel on it could be lifted and wheeled by the frame. While in the frame, the panel was held in place by screws which applied pressure to the sides and top of the panel through a wooden board and a layer of rigid foamed plastic. A further layer of sponge plastic material placed between the panel and the rigid plastic took up any slight irregularities in the surface. Thus the panel was surrounded on all edges by rigid foamed plastic. It had originally been planned to test the panels under conditions of temperature gradient from face to face, so that the plastic slabs were provided to isolate the panel thermally at the edges. Tests under such conditions were not made, however, although the plastic was useful to seal the panel edges.

When the frame was moved into position against the chamber, the foamed plastic slabs surrounding the panel pressed against a soft sponge plastic cemented to the chamber. By tightening four bolts connecting the frame and chamber a tight seal was obtained. A window in the back wall of the chamber permitted adjustment of the water pipe and when closed allowed observation of the wetted surface of the panel during the test. The frame and the pressure chamber are shown in Fig. 2.

During a test, water was supplied to the pipe at a rate of 0.5 gal per min to maintain a film over the panel surface. Air-pressure difference across the panel was maintained at 2.5 in. of water (13 lb per sq ft). The actual pressure difference across the walls of a building depends on many factors which include wind speed and height and shape of the building (**4, 5**). The pressure difference of 2.5 in. of water used in the tests is about equal to that which might result from a 70-mph wind blowing against a building. The test conditions were therefore considered to represent heavy rain accompanied by high wind.

Test Specimens

Bricks

Clay and shale bricks from three different manufacturers and concrete bricks from two sources were used in the tests. The clay and shale bricks were selected to provide, among the three types, a wide range in the property of initial rate of absorption or suction. This may be determined by a standard ASTM test[2] and is generally recognized[3] as an important factor in the bonding of mortar to brick. From each of the three lots, bricks were selected for panel construction to be within a relatively narrow suction range.

The clay and shale bricks were designated A, B, and C, the first two being made by the extrusion method and cored. Brick A was low in suction; two ranges of suction namely 2 to 4 and 5 to 8 g per min per 30 sq in. were used. Brick B was moderate in suction, and again two ranges in this case, 15 to 19 and 20 to 24 g were used. Brick C, a shale brick made by the dry-press method, was quite high in suction; four suction ranges, 60 to 69, 70 to 79, 80 to 89, and 90 to 99 g were used. Brick C was obtained in the normal size, as well as in a much larger size, $11\frac{1}{2}$ in. long, $5\frac{1}{2}$ in. wide, and normal height. The latter were not classified for suction and were used as taken from the pile.

The concrete bricks also were used as they came from the pile without classification into a particular suction range, although both types were relatively high in suction. Brick D was coarse in texture and brick E fine-textured, owing to the different aggregates used. All concrete and clay and shale bricks were smooth-surfaced and when used in building panels were laid dry in the mortar. No attempt was made to alter the suction by wetting the bricks before use.

Properties of the various bricks are listed in Table I.

Mortars

Two mortars of cement, lime, and sand were used. One was relatively high in lime content, containing 1 part portland cement, 2 parts lime, and 9 parts sand by volume. The other was high in cement content, with 1 part portland cement, $\frac{1}{4}$ part lime, and $3\frac{3}{4}$ parts sand by volume. The lime was prepared from a normally hydrated lime soaked in water overnight before use. It was proportioned by volume as a putty. A natural sand was used, the particle-size grading of which conformed to ASTM Specification C 144.[4] It was proportioned on the basis of volume in a dry condition.

Mortar materials were thoroughly mixed in a mechanical mixer, each batch consisting of about $1\frac{1}{2}$ cu ft. When mixed, the mortar was slightly stiff in consistency; it was delivered to the bricklayer's board in this state so that he could add water as he desired.

Water retentivity values of mortars were measured by ASTM Methods C 110[5]; the 1:2:9 mortar had an average value of 85, while that of the $1:\frac{1}{4}:3\frac{3}{4}$ mortar was 67.

TABLE I.—PROPERTIES OF THE BRICKS.

Brick	Suction, g per min per 30 sq in.	Absorption, per cent dry weight		Saturation Coefficient
		24-hr Immersion	5-hr Boil	
A	2 to 8	0.7 to 4.3	1.9 to 5.3	0.35 to 0.86
B	15 to 24	7.0 to 9.5	8.6 to 11.0	0.78 to 0.86
C	60 to 99	7.2 to 8.8	9.6 to 11.5	0.73 to 0.78
C (large size)	52 to 73	4.6 to 10.3	6.8 to 11.1	0.68 to 0.93
D	12 to 65	5.6 to 6.4	[a]	[a]
E	83 to 124	8.1 to 9.0	[a]	[a]

[a] Not measured.

[2] Methods of Sampling and Testing Brick (C 67 – 57), 1958 Book of ASTM Standards, Part 5, p. 59.

[3] Specification for Building Brick (Solid Masonry Tentative Revision of Specifications C 62) (C 62 – 58) 1959 Supplement to 1958 Book of ASTM Standards, Part 5, p. 195.

[4] Tentative Specification for Aggregate for Masonry Mortar (C 144 – 52 T), 1958 Book of ASTM Standards, Part 4, p. 432.

[5] Methods of Physical Testing of Quicklime and Hydrated Lime (C 110 – 58), 1958 Book of ASTM Standards, Part 4, p. 249.

Panel Construction and Testing

Panels were constructed by a bricklayer of many years' experience who was instructed to work carefully and to fill all the joints completely. His observations on the working properties of the various materials are discussed later.

Mortar joints on one side of the panel were concave-tooled. In some cases this was done shortly after the bricks were laid, but in other cases only after some hours, depending on the rate of stiffening of the mortar. The bricklayer was allowed to tool the joints when he considered it should be done. In panels that were 8 and 12 in. thick, common bonding patterns were used, each sixth course composed of header bricks.

Flashings were installed at the base of the panels to divert the spray and leakage water at each side. Two materials were used, both satisfactorily: a wire-reinforced asphalt-impregnated fabric and a thin-gage copper sheet. In some panels the flashings were laid about 2 in. in the mortar joint as the panel was being constructed, but it was found easier in later panels to rake our the fresh mortar joints to a depth of about $\frac{1}{2}$ in. and insert the flashing and fasten it in place with caulking material.

When the bricklayer completed a panel, the edges and top surfaces were covered with a mortar parget to level them. When the panel appeared dry on the surface, caulking material was applied to the front and back faces in a strip near the edges. In this way a 40-in. width of brickwork was left uncovered and exposed to the water spray in the test. The panels were stored under uncontrolled and variable temperature and humidity conditions for between 30 and 40 days until tested.

During the test, observations were made of the time taken for dampness to appear on the back of the panel, the development of damp areas, and the rate of leakage of moisture through the panel at certain times after the start of the test. The rate of leakage was usually measured at 5 and 30 min, and 1, 2, 3, 6, 24, and 48 hr after the start of the test.

Influence of Brick and Mortar on Moisture Penetration

Each of the three clay and shale bricks was used with two mortars in constructing 8-in. panels, and each combination was made in duplicate, resulting in 12 panels in all. The two concrete bricks were also used with two mortars, but only a single panel of each combination was made and one of them was broken accidentally and not tested.

Resistance of the various panels to moisture penetration varied markedly.

TABLE II.—INFLUENCE OF TYPE OF BRICK AND MORTAR ON MOISTURE PENETRATION OF 8-IN. PANELS.

Brick	Suction, g per min per 30 sq in.	Mortar Portland Cement: Lime:Sand, by Volume	Mortar Rate of Leakage, lb of water per min per 100 sq ft of panel	
			Maximum	At 6 hr
A	2 to 4	1:2:9	0	0
	5 to 8	1:2:9	0	0
	5 to 8	1:$\frac{1}{4}$:3$\frac{3}{4}$	0	0
	5 to 8	1:$\frac{1}{4}$:3$\frac{3}{4}$	0	0
B	15 to 19	1:2:9	0.14	0.06
	15 to 19	1:2:9	0.05	0.01
	20 to 24	1:$\frac{1}{4}$:3$\frac{3}{4}$	2.48	1.67
	20 to 24	1:$\frac{1}{4}$:3$\frac{3}{4}$	0.89	0.71
C	70 to 79	1:2:9	0.48	0.48
	80 to 89	1:2:9	0.65	0.65
	60 to 69	1:$\frac{1}{4}$:3$\frac{3}{4}$	3.40	2.09
	90 to 99	1:$\frac{1}{4}$:3$\frac{3}{4}$	3.46	1.28
D	12 to 65	1:2:9	1.42	1.24
	12 to 65	1:$\frac{1}{4}$:3$\frac{3}{4}$	0.30	0.25
E	83 to 124	1:2:9	1.67	[a]

[a] Not recorded.

In a few cases there was no leakage of water through the panel, in others only a slight amount, while in some cases moisture passed through the panels very freely. Rates of leakage are compared in Table II. During the tests it was found that the rate changed, rising to a maximum value and then decreasing; the panels, therefore, are compared on the basis of the maximum leakage rate recorded 6 hr after the start of the test. Leakage rate is expressed as pounds of water per minute passing through 100 sq ft of panel.

No leakage water came off the backs of panels in which brick A was used with either mortar. For two panels of this brick, there was no dampness visible on the back of the panel after 24 hr of test, and the other two panels had only a few small damp spots in the mortar joints.

Panels of brick B and the 1:2:9 mortar allowed a relatively slight amount of leakage to take place, while with the same mortar panels of brick C were considerably worse. With the 1:$\frac{1}{4}$:3$\frac{3}{4}$ mortar, however, bricks B and C both had a much higher rate of leakage than with the 1:2:9 mortar. In the case of brick B, the pairs of panels for the two mortars were constructed of bricks of slightly different suction values, which may have increased the effect of the change in mortar.

The reproducibility of results was not impressive, particularly for panels of brick B and 1:$\frac{1}{4}$:3$\frac{3}{4}$ mortar. Variation in results within pairs of panels, however, was not sufficient to mask the great differences in leakage characteristics resulting from the type of brick and mortar used. For clay and shale bricks it appeared that the leakage rate increased as the suction of the brick increased, and except for panels of the low-suction brick, the leakage rate was much higher for the 1:$\frac{1}{4}$:3$\frac{3}{4}$ mortar than for the 1:2:9 mortar. It is well known that different limes have different effects on mortar properties such as water retentivity and accordingly on the extent of bond. The same improvement in resistance to moisture penetration with increased lime content of mortar which was noted with the particular lime used, may not occur with other limes.

The higher-suction concrete brick E with 1:2:9 mortar produced a panel of slightly greater leakage rate than that of brick D with the same mortar. The panel of brick D with the 1:$\frac{1}{4}$:3$\frac{3}{4}$ mortar, however, was lower in leakage rate than that with the 1:2:9 mortar, which was the reverse of the situation for clay bricks B and C. Later tests

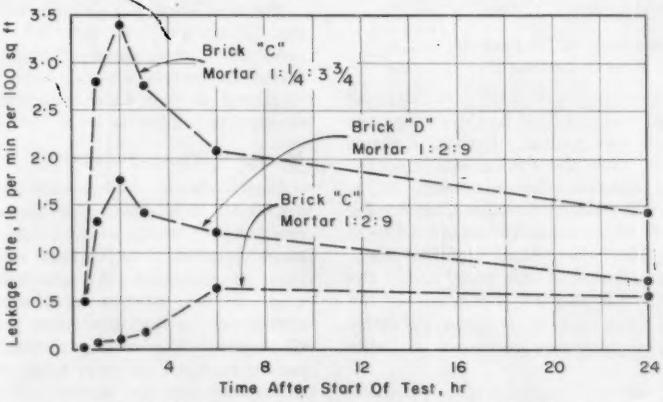

Fig. 3.—Change of leakage rate of 8-in. panels during test.

of two 4-in.-thick panels of concrete brick E were made with the result that the panel with 1:¼:3¾ mortar had a much higher leakage rate than that with the 1:2:9 mortar. The influence of mortar composition on the moisture penetration characteristics of concrete brick masonry therefore is not clear.

Change of Leakage Rate During Test

The rate of leakage changed during the tests, rising to a maximum value in the first few hours and decreasing as the test continued. Examples of the change for three panels are shown in Fig. 3.

White streaks and discoloration appeared on the backs of some panels. This material, if deposited in openings in the panel, could presumably reduce leakage. Analysis of a sample obtained from the back of one panel indicated that it was mainly calcium carbonate.

Influence of Panel Thickness on Moisture Penetration

With both mortars and brick C, panels were constructed in thicknesses of 4, 5½, 8, and 12 in., the second thickness being that of the oversize brick. Results of the tests of these panels are compared in Table III, on the basis of the maximum rate of leakage recorded during the test. The time taken for the first dampness to appear on the back of the panel after the start of the test is also shown.

The 4- and 5½-in. panels of both mortars, and the 8-in. panel of the high-cement mortar started to leak very quickly and in relatively large quantity. However, as the panel thickness increased the leakage rate generally decreased, so that the time interval became longer before dampness appeared on the back. For the 12-in. panel with 1:2:9 mortar dampness appeared after 23 min of test, although no no water came off the back of the panel for over 3 hr. In the case of the 12-in. panel of 1:1¼:3¾ mortar, dampness appeared on the back after 16 min, but no leakage water came off the back for 1 hr.

Influence of Air Pressure on Rate of Leakage

Although the leakage rate changed during test, after 24 hr the change was usually very gradual. In the test, of two panels, when the leakage rate was thus fairly constant, the air-pressure difference was reduced in stages to determine the effect on the rate of leakage. One of the panels was of brick C, 5½ in. thick. Leakage rates of this panel under the normal air-pressure difference of 2½ in. of water (used in the tests) and under reduced pressures are shown in Table IV.

The leakage rate of a very permeable 4-in. panel of brick C was measured under the normal test conditions of 2½ in. air-pressure difference and then under no air-pressure difference, with the result that the rate of leakage dropped from 10.3 to 1.9 lb of water per min per 100 sq ft of panel. In both tests, therefore, it is apparent that the rate of leakage was influenced greatly by the air-pressure difference across the panel.

TABLE III.—INFLUENCE OF THICKNESS OF PANELS OF BRICK C ON MOISTURE PENETRATION.

Panel Thickness, in.	Maximum Leakage Rate, lb per min per 100 sq ft		Time for Dampness To Appear on Back	
	Mortar 1:2:9	Mortar 1:¼:3¾	Mortar 1:2:9	Mortar 1:¼:3¾
4	4.61	10.64	30 sec	15 sec
5½	3.01	5.43	30 sec	1½ min
8	0.65	3.46	9 min	½ min
12	0.71	0.80	23 min	16 min

TABLE IV.—INFLUENCE OF AIR-PRESSURE DIFFERENCE ACROSS PANEL ON RATE OF LEAKAGE.

Air Pressure Difference, in. of water	Leakage Rate, lb per min per 100 sq ft
2.5	0.58
1	0.21
0.5	0.09
0	0.02

Leakage at Mortar Joints and Through Bricks

When moisture penetration took place it usually occurred first in the mortar joints, although for panels of brick C and concrete brick dampness frequently appeared on the surface of a brick while the mortar joints surrounding it appeared to be dry. Small bubbles were sometimes seen at the brick surface when moisture came through it. In most panels, moisture penetration through the joints showed up first at the header bricks. In some very permeable panels air leakage through the mortar joints, between mortar and brick, could be detected by placing the hand near the panel surface.

To determine the proportion of leakage attributable to the mortar joints, three panels of brick C (5½-in. thickness) were constructed, one of 1:2:9 mortar, the second of 1:¼:3¾ mortar and the third with caulked mortar joints. In the last case, on completion of the panel the joints were raked out on each side to a depth of about ½ in. and subsequently packed with a caulking material. The results of these tests are shown in Table V, on the basis of the maximum rate of leakage recorded during the test.

For this brick it was indicated that the proportion of moisture which penetrated the panel through the bricks themselves was relatively small compared to that which penetrated at the mortar joints.

TABLE V.—COMPARISON OF MORTAR-JOINT LEAKAGE AND LEAKAGE THROUGH BRICKS[a] FOR PANELS OF BRICK C, 5½ IN. THICK.

Mortar	Maximum Leakage Rate lb per min per 100 sq ft
1:2:9	3.01
1:¼:3¾	5.43
Raked and caulked	0.60

[a] Assuming no leakage through caulked joint.

TABLE VI.—FLOW VALUES OF MORTARS USED WITH VARIOUS BRICKS.

Brick	Mortar Flow, per cent	
	Mortar 1:2:9	Mortar 1:¼:3¾
A (suction 2 to 8 g)	109.5	118
B (suction 15 to 24 g)	114	120
C (suction 60 to 99 g)	114.5	126
D (suction 12 to 65 g)	114	120
E (suction 83 to 124 g)	117	129
Average for all bricks	114	123

Mortar Working Qualities

Comments by the bricklayer and differences in bricklaying methods indicated that working characteristics differed appreciably for various combinations of materials. No attempt was made to mix mortars to a standard consistency or to have them used in that state. The bricklayer could temper the mortar with water to adjust the consistency as he wished. Records were made of mortar flow, as an indication of consistency, as the bricklayer used it with the various bricks. The average flow values of several measurements are shown in Table VI and indicate that the consistency was adjusted according to the type of brick used. As the suction of the brick increased the mortar was made wetter to produce a higher flow value.

With a given brick the flow of the high-cement mortar was consistently much greater than that of the high-lime mortar. The bricklayer was very critical of the former mortar, since it was very difficult to trowel and to set bricks in it. He stated that it needed more lime to make it suitable, and although in this work he is willing to use it he pointed out that, if specified for an actual building, it would not be acceptable to bricklayers, who would adjust the workability by adding more lime. The 1:2:9 mortar was much more plastic and workable, and he was satisfied with it. It stayed workable for a long period, whereas the

1:$\frac{1}{4}$:3$\frac{3}{4}$ mortar stiffened on the board in a short time and required frequent tempering with water to maintain its workability. It was sensitive to the amount of water added, and although it could be "worked up" to some degree of plasticity it stiffened upon standing, with segregation of water. In short, the water retention values of the mortars appeared to reflect their working properties.

The bricklayer believed that the sand was too coarse and resulted in harsh mortar, but it was well-graded according to specification requirements. A sample of another local sand he had frequently used was supplied by him for inspection. It did not meet specification requirements for grading, however, as it contained considerably too much fine material. Although the bricklayer originally expressed the opinion that the sand used was too coarse, he later tributed mortar harshness to insuffi- t lime. It was not clear therefore, hich of the two factors, in his opinion governed the working qualities of the mortar.

The bricklayer also pointed out that mortar mixing on an actual job is the work of the helper and that there is no consistent proportioning of materials; they are mixed, adding lime as needed, to produce a mortar that slides easily off the shovel. The "feel" decides its acceptability.

The bricklayer said his normal procedure was to lay out a furrowed mortar bed somewhat deeper than the desired joint thickness so that the bricks could be shoved or tapped down into it to the required level. In the construction of the panels, however, he was instructed to use a flat, not furrowed, mortar bed. With the high-suction bricks and high-cement mortar he was not able to shove the bricks easily into place; thus, the mortar bed was laid out only slightly thicker than the final size to facilitate setting.

The length of mortar bed laid out in advance of setting bricks was left to the bricklayer's preference. With the high-suction brick C he usually laid out mortar for only one brick at a time; with brick B and the high-cement mortar he again usually laid out mortar for one brick only; but with the 1:2:9 mortar he spread enough for two or three bricks. With the low-suction brick A and both mortars, he laid out mortar for two or three bricks and often for the full panel width of five bricks. This brick was slippery on the mortar bed and "floated" out of position easily by the shoving of adjacent bricks. Brick C required an excessive amount of tapping into position because of the rapid consolidation of the mortar when the brick came into contact with it. The medium-suction brick B appeared to be easily placed in either mortar.

It was customary for the bricklayer to tap all the types of bricks with the trowel when setting them in the mortar, but much more tapping was usually needed when the high-cement mortar was used. Tapping sometimes appeared to open vertical joints a small amount, because of slight horizontal movement of the bricks, and some appeared to "rock" on the mortar bed when laid, creating a wedge-shaped void between mortar and brick at the edge. This was particularly noticeable with the 5$\frac{1}{2}$-in. wide brick.

Full bed joints and full exterior vertical joints were used, in the latter case by "buttering" the end of the brick with a large amount of mortar before it was laid. In the 8- and 12-in. walls, a vertical "collar" joint separated the layers of bricks, and the bricklayer attempted to fill this joint by "slushing" mortar in from above, working it down by cutting it vertically with the trowel. Two panels broken accidentally revealed that these joints were almost always incompletely filled and contained large voids. The method attempted for filling them therefore was not effective.

Effect of Outdoor Exposure on Moisture Penetration

After the first leakage test, many of the panels were stored out-of-doors for 2 yr or more, then retested to determine the effect of weathering on their moisture penetration properties. In most cases there was improvement in resistance to moisture penetration or no change. One panel was slightly more permeable as a result of exposure. In all cases the change in moisture penetration properties was not appreciable.

Panels of the low-suction brick A which were highly resistant in the original test were the same on retesting. Panels of bricks B and C, with both mortars, were less permeable on the second test. Slightly greater leakage occurred in one of the concrete brick panels as a result of exposure.

Summary and Conclusions

Resistance of brickwork panels to moisture penetration varied greatly depending on the brick and mortar combination; the suction of clay and shale bricks and the mortar composition were important factors, confirming the results of studies made elsewhere. For panels of concrete bricks, however, the influence of mortar composition was not clear.

The tests indicated that moisture penetration was associated with the mortar-brick interface. Although moisture penetration through the bricks took place with some types of bricks, the major amount of leakage appeared to be at the interface. In many of the 8-in. panels tested the header courses contributed greatly to the early leakage of the panels.

Information was obtained for one type of brick on the effect of wall thickness on moisture penetration, and on the effect of the air-pressure difference across a panel on its leakage rate; both of these factors had an appreciable influence on leakage.

Observations made during panel construction showed that the bricklayer's technique varied to adjust to changes in the properties of the materials, resulting in substantial differences in mortar flow, tapping of bricks, and mortar "spread out" for the various types of bricks and mortars used.

Outdoor exposure of panels for two or more winters did not have any appreciable effect on moisture penetration for the materials used. More extensive studies made elsewhere (6) of the effect of weathering on moisture penetration of solid brick walls have given similar results.

The studies reported in this paper are of a preliminary nature and the scope of the investigations only broad enough to indicate the importance of some factors influencing moisture penetration of brick masonry. Further studies are being made in the Division of Building Research on some of these factors.

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A High-Temperature, Vacuum, Axial Fatigue Testing Machine

By R. I. STEPHENS and G. M. SINCLAIR

This paper describes equipment developed to test thin-walled refractory metal specimens in a vacuum under repeated axial load at temperatures up to 2500 F. The machine is of the constant-displacement type with an eccentric and crank mechanism for varying the alternating stress, mean stress, and frequency of cycling. Stresses in the specimen are easily calculated from $\sigma = P/A$, where P is the axial load measured by a ring dynamometer and A is the cross-sectional area of the specimen. The thin-walled tubular specimen is heated by an internal tungsten heating element. The evacuated test chamber is completely visible through a pyrex bell jar seated on an O-ring seal. Axial load is transmitted into the vacuum chamber through a copper alloy bellows. Preliminary results are given of fatigue tests on commercially pure arc-cast molybdenum specimens subjected to fully reversed stresses at 1700 F and 875 cpm.

SINCE THE INTRODUCTION of the jet engine, there has been an ever-increasing demand for materials capable of withstanding higher temperatures and higher stresses. Engineering trends in both new and old fields call for higher operating temperatures and stresses in order to increase efficiency. However, material requirements far exceed material capabilities. At the present time the predominant high-temperature metals are nickel-, cobalt-, and chromium-base alloys. These alloys have nearly reached their peak working temperatures, which are limited by their melting and recrystallization temperatures. Since the recrystallization temperature is usually the maximum working temperature for a metal, the metals with high recrystallization and melting temperatures—the refractory metals—are receiving the greatest attention in the development of alloys capable of withstanding temperatures above 1700 F.

One of the greatest obstacles in the use of the refractory metals is oxidation. Molybdenum, columbium, and tungsten, which are receiving the most attention, are not oxidation-resistant at the desired working temperatures. However, coatings and alloys may be found that will reduce or eliminate oxidation problems.

To determine mechanical and physical properties of the refractory metals under nonoxidizing conditions, tests may be performed in an inert atmosphere or in a vacuum. Many high-temperature tests have been made with presently developed refractory specimens and parts, but most strength tests have dealt primarily with creep-rupture phenomena (**1**, **2**, **3**).[1] The determination of fatigue properties lags drastically behind the determination of other properties. High-temperature fatigue data on refractory metals is at a minimum because commercial fatigue testing equipment capable of isolating test specimens from oxidizing atmospheres is not available and special fatigue equipment has only recently started to be developed.

Other High-Temperature, Vacuum, Fatigue Equipment

Danek and Achter (**4**) have described a high-temperature, vacuum, fatigue testing apparatus, developed at the U. S. Naval Research Laboratory, in which thin sheet specimens were vibrated at resonant frequency in reversed bending at a temperature of 1500 F. Their tests were carried out in a compact vacuum chamber at a pressure of 5×10^{-6} mm of mercury. The problem of transmitting motion into the vacuum chamber was solved by a magnetic coupling driven at the resonant frequency of the test specimen. While this apparatus simplified attainment of a vacuum, it had several disadvantages: (1) a mean stress other than zero could not be obtained, (2) the frequency was restricted to the resonant frequency for the specimen and grips, (3) the resonant stress amplitude was difficult to control within narrow limits, and (4) stress calculations were difficult.

Object

This paper describes a versatile, high-temperature, vacuum, fatigue testing machine and also reports preliminary high-temperature fatigue data for molybdenum obtained with this equipment.

RALPH I. STEPHENS received his B.S. in General Engineering, 1957, and his M.S. in Theoretical and Applied Mechanics, 1960, from the University of Illinois. For the past three years he has been an instructor in Engineering Graphics and Theoretical and Applied Mechanics at the University of Illinois.

G. M. SINCLAIR is a research professor in the Department of Theoretical and Applied Mechanics at the University of Illinois. He has been a member of ASTM Committee E-9 on Fatigue since 1949, and has contributed numerous articles on the fatigue and fracture behavior of metals. In recent years he has turned his attention to special problems associated with refractory metals.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

Description of Machine

Machine Capabilities

Figures 1 and 2 show a complete working arrangement and schematic of the machine. With this equipment it is possible to test thin-walled, tubular specimens at different frequencies and temperatures up to 2500 F under completely reversed stress, and also under an alternating stress superimposed on either tensile or compressive mean stress. Therefore, data can be obtained at elevated-temperature conditions ranging from predominately creep (low alternating stress amplitude and high mean stress) to that of predominately fatigue (high alternating stress amplitude and zero mean stress). The heating element limits the temperature to 2100 F, but since a tungsten heating coil is used, the maximum operating temperature can be increased with modifications in the coil support.

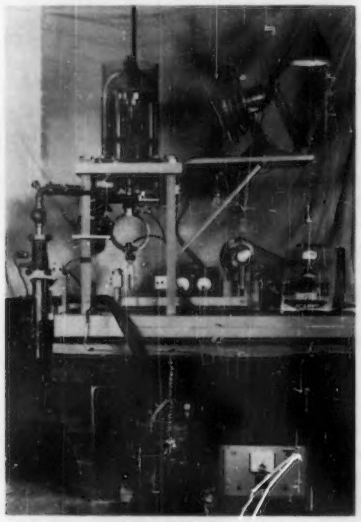


Fig. 1.—High-temperature, vacuum fatigue machine.

Loading Facilities

The maximum working load for the machine is ±2000 lb. This permits specimens with a nominal cross-sectional area of 0.02 sq. in. to be subjected to alternating stresses up to ±100,000 psi. The machine is of the constant-displacement type; the motion, or load, is applied to the specimen through a horizontal level arm and an adjustable connecting rod and eccentric (see Figs. 2 and 3). The eccentric is driven by a 1750-rpm, constant-speed motor through a pulley arrangement to allow the load frequency to be varied. A turnbuckle on the connecting rod can be adjusted to compensate for thermal expansion in the specimen and grips. It is also used in conjunction with the adjustable eccentric to establish the maximum, minimum, and mean stress levels.

The load is transmitted to the specimen through a vertical flex-bar at *Z*, (Fig. 3) and a calibrated ring dynamometer. The dynamometer measures the applied load and consists of four active SR-4, type AD-7 electrical resistance strain gages which are fastened to a thick-walled ring as shown at *Y* (Fig. 3). Findley (5) describes an axial-load fatigue testing apparatus designed for room-temperature fatigue tests which was used as a basis and guide in designing some of the mechanical features of this machine.

Specimen Alignment

All the parts of the testing apparatus were carefully machined to minimize misalignment. Two mutually perpendicular horizontal adjustable flex bars outside the vacuum chamber and one horizontal adjustable flex bar inside the vacuum chamber maintain the action line of the load and the displacement in the proper planes. The brass base plate which supports the upper gripping system and the bell jar can be adjusted to the proper location before being bolted down. Since the thin-walled tubular specimen has a large outside diameter, the alignment problem is less critical than for small-diameter solid specimens. The high operating temperature also reduces the demand for highly critical alignment.

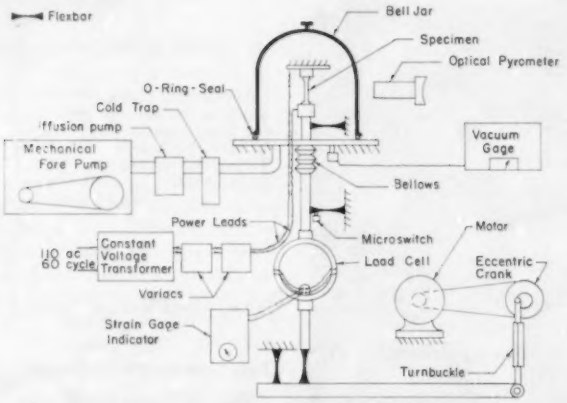


Fig. 2.—Schematic layout of machine.

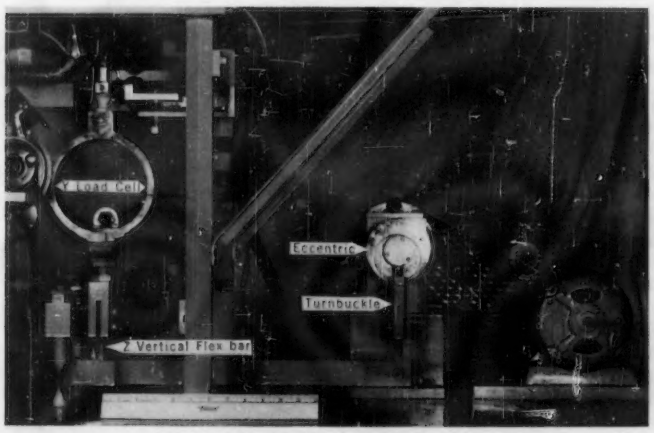


Fig. 3.—Loading arrangement.

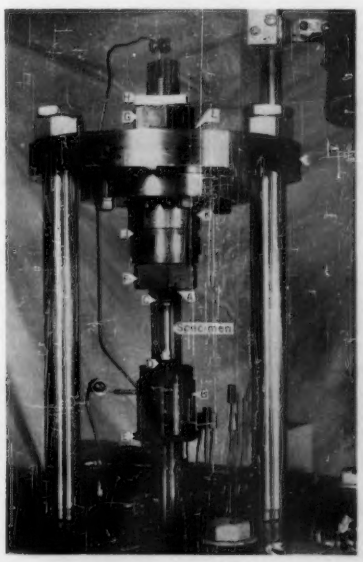


Fig. 4.—Upper support and gripping arrangement.

It was possible to insert and remove the threaded specimens in both grips with only finger motion, except for the final locking and the initial unlocking. This is an indication of good alignment.

Specimen Grips

Figure 4 shows the method of holding the specimen. A $\frac{1}{2}$-20 NF thread at each end of the specimen screws into the upper and lower grips, *A* and *B*. Stainless steel lock nuts, *C* and *D*, lock the specimen to the grips. Lock nut *E* secures the lower grip to the vertical shaft, which transmits the load to the specimen. The upper grip, *A*, is held by lock nuts *F*, *G*, and *H*, and a horizontal support plate, *I*. A $\frac{5}{16}$-in. diameter hole along the longitudinal axis throughout the length of the upper grip allows space and a guide for the heating element supports. The brass washers, *J* and *K*, and the brass flange, *L*, compensate for the large thermal expansion of the upper grip which tends to loosen nuts *G* and *H*.

Vacuum System

The vacuum is produced by a conventional mechanical vacuum pump, air-cooled diffusion pump, and a cold trap surrounded by liquid nitrogen when needed. The test chamber is formed by a pyrex bell jar seated on an O-ring seal embedded in a 1-in. thick brass base plate. The glass bell jar allows the entire test to be visible, which permits the use of an optical pyrometer to measure temperature. A high-vacuum Philips gage tube, located at the bottom of the test chamber, and a portable electronic Philips gage are used to measure the vacuum. Electrical power is brought into the vacuum through four kovar seals. In addition to the power cables, 14 separate leads are brought into the system to permit various measurements. Specimen load is brought into the vacuum through a brass bellows soldered to the bottom of the brass base plate and the vertical shaft.

Temperature Control and Measurement

The heating element (Fig. 5) consists of a 0.020-in. diameter tungsten wire wound into a 3- to 3.5-in. long coil of from 60 to 80 turns on a $\frac{3}{16}$-in. mean coil diameter. The electrical-resistance heating element operates below 11 amp and 40 v. The coil is wound on a threaded brass rod with 40 threads per in., and is supported by inserting a quartz or synthetic sapphire rod through the windings. A stainless steel connector fastened to the tungsten coil is protected from shorting against the upper grip by inserting part of the lower coil support into a larger quartz tube. This outer tube also helps to keep the coils centered in the specimen and thus prevents shorting at the specimen. A $\frac{1}{4}$-in. long quartz tube washer at the bottom of the coil prevents the lower coils from shorting. The complete heating element is placed inside the specimen and grips and rests in a small tapered hole countersunk in the top of the vertical shaft which supports the lower grip. The maximum temperature of the heating element is limited by the type of coil support. Temperatures up to 2100 F were reached with a clear fused quartz support, and above 2500 F with a synthetic sapphire support.

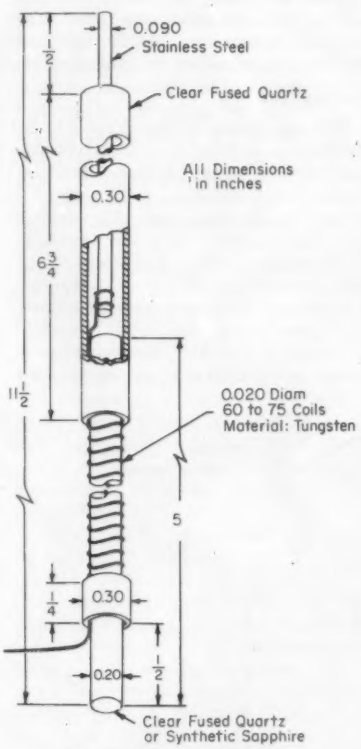


Fig. 5. Heating element.

The power to the heating element is controlled by two variacs connected in series for greater sensitivity. A constant-voltage transformer in series between the variacs and a 110-v, 60-cycle, a-c wall outlet reduces temperature fluctuation. A microswitch automatically turns off the power and stops the loading cycles when the specimen breaks.

Since heat is transferred from the coils by radiation, it was thought that radiation shields would have to be placed around the specimen to reduce heat losses in order to obtain the desired elevated temperatures. It was found that the shields were not necessary. At 1650 F, a length of about $\frac{3}{4}$ in. of the specimen was heated to uniform temperature over the $1\frac{1}{4}$-in. gage length, and at higher temperatures the uniform temperature zone was larger.

Undesirable heat transfer occurred at the soldered joint of the bellows and the vertical shaft, the kovar seals, the pyrex bell jar, and at the O-ring which seals the bell jar. Two fans, one mounted at the bellows and one at the bell jar, reduced the temperature of these parts. A water path was drilled into the brass base plate to cool the O-ring seal, kovar seals, and the top connection of the bellows.

The temperature was measured with an optical pyrometer calibrated by embedding chromel-alumel thermocouples into a finished molybdenum specimen and relating the pyrometer reading to the thermocouple temperature. This calibration was necessary owing to refraction of the bell jar and also because the specimen does not approach the black body conditions usually assumed for optical pyrometry.

Welded thermocouples, and thermocouples held against the specimen by tightly wrapped wire, were tried as a means of measuring temperature, but proved to be unsatisfactory and therefore were abandoned in favor of the optical pyrometer.

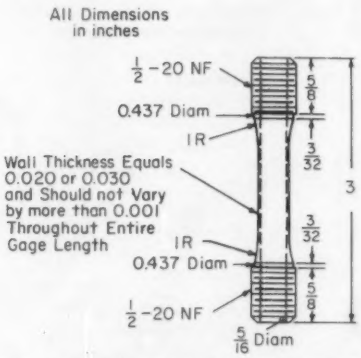


Fig. 6.—Details of thin-walled tubular test specimen.

Test Specimens

The specimens tested in this machine must be tubular in order to insert the heating element. An example of the type and size of specimen used is shown in Figs. 6 and 7. The over-all length is 3 in., and the inside diameter is $\frac{5}{16}$ in. The nominal wall thickness is 0.02 or 0.03 in., which gives a cross-sectional area of about 0.02 or 0.034 sq in., respectively. The wall thickness can vary from specimen to specimen as long as the thickness is uniform for each specimen. The molybdenum specimens were machined from $\frac{5}{8}$-in. diameter by 3-in. long blanks. The inside diameter was drilled and then honed to remove internal burrs and pits and to form a smooth internal finish. The outside area was polished in a longitudinal direction to give uniform thickness and a smooth external finish.

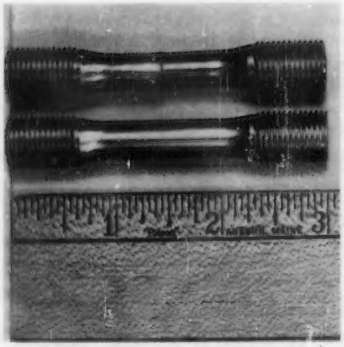


Fig. 7.—Test specimens showing location of fracture.

stallization. The specimen had an ASTM mean grain size of eight. Figure 9(*b*) shows the microstructure on a transverse section of a 0.020-in. wall-thickness specimen after testing at 1700 F. In both photographs, the upper edge is the outside surface of the specimen and the lower edge is the inside surface. It is evident that some grain growth occurred throughout the section, with the greatest growth occurring on the inside surface. However, a limited microstructure study was made, and therefore, it is not known whether the greater grain growth on the inside surface is representative of all specimens.

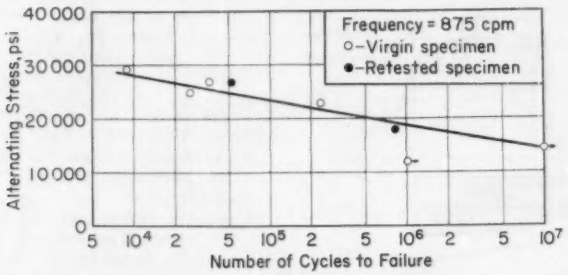


Fig. 8.—*S-N* curve for commercially pure arc-cast molybdenum tested at 1700 F under fully reversed loads.

Stress Calculations

Both static and dynamic stresses in the specimen were determined by dividing the applied load by the original cross-sectional area. The magnitude of the load for any desired mean or alternating stress was predetermined from this same formula and set using a calibrated SR-4 strain indicator connected to the ring dynamometer. Some drift in the load readings occurred during testing at high temperature due to creep-relaxation phenomena, and therefore, the load had to be periodically adjusted. At room temperature the drift was negligible.

Results

Figure 8 shows an *S-N* curve for commercially pure arc-cast molybdenum specimens tested under fully reversed loading at a temperature of 1700 F and a pressure of approximately 5×10^{-4} mm of mercury. A chemical analysis of the molybdenum as received is given in Table I. The specimens were recrystallized at 2250 F for 4 hr after machining. The specimen temperature as measured with a calibrated optical pyrometer was kept within ±30 F of the calibration curve. The tests were stopped periodically to remeasure the loads and to verify the adjustments that were made during cycling to compensate for drift.

Figure 9(*a*) shows the microstructure on a transverse section of a 0.030-in. wall-thickness specimen after recrystallization.

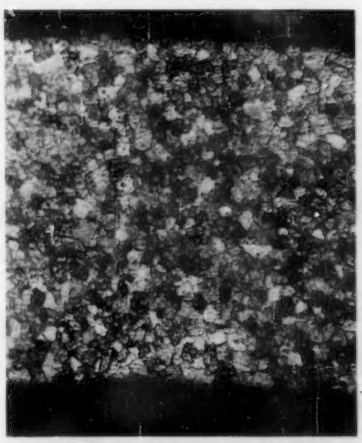
As shown in Fig. 8, a straight line was drawn through the mean of the plotted points at 1700 F, since a gradual curved line, which might be expected at this temperature, could not be justified from the data obtained. A smooth curve was drawn through the mean of the points at room temperature as shown in Fig. 10, because a definite fatigue limit could not be determined for the data obtained. The room-temperature fatigue data were obtained only to compare results with similar results from other equipment

Discussion

The machine described is quite versatile, since the mean stress and frequency of cycling can be adjusted to any reasonable level. The stress in the axially loaded specimen is not dif-

TABLE I.—CHEMICAL ANALYSIS BY WEIGHT PER CENT OF COMMERCIALLY PURE ARC-CAST MOLYBDENUM, AS RECEIVED.

Carbon	0.005–0.030
Aluminum	<0.002–0.005
Magnesium	<0.001–0.005
Calcium	<0.001–0.005
Sodium	<0.001–0.005
Potassium	<0.001–0.005
Silicon	<0.008–0.050
Iron	<0.006–0.010
Lead	<0.0005–0.001
Tin	<0.005
Chromium	<0.001–0.010
Nickel	<0.0005–0.005
Cobalt	<0.008
Copper	<0.001–0.005
Tungsten	<0.001–0.005
Manganese	<0.0003–0.005



(*a*) After recrystallization—0.030-in. wall thickness.

(*b*) After testing at 1700 F—0.020-in. wall thickness.

Fig. 9.—Microstructure of test specimen. Magnification 100×, reduced for publication.

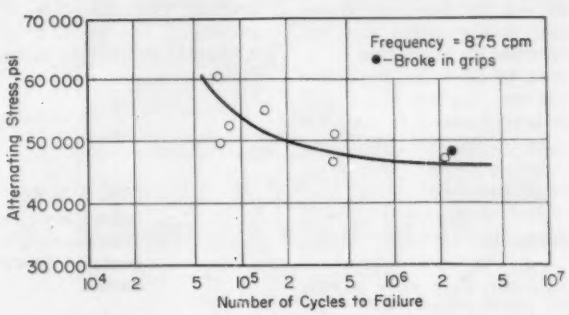


Fig. 10.—*S-N* curve for commercially pure arc-cast molybdenum tested at room temperature under fully reversed loads.

ficult to determine, and, since specimens with relatively large outside diameters are used and high temperatures are present, adequate alignment is not difficult to obtain. The problem of transmitting motion into a vacuum was solved adequately by means of a metal bellows. Since the axial displacement of the bellows is quite small, even for highly stressed specimens, the possibility of the bellows failing in fatigue is very slight. The internal heating element gave very satisfactory temperature uniformity, but became brittle after one test, and great care had to be taken while removing and replacing specimens so as not to break the coils.

S-N curves for molybdenum subjected to rotating bending obtained by Brock and Sinclair (6) are included here (Fig. 11) to give a more complete comparison of fatigue behavior of molybdenum at elevated temperatures.

In future work it should be possible to monitor specimen strains, since ample space is available for gages, and electrical leads for monitoring the gages were installed during fabrication.

Acknowledgment:

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Professors T. J. Dolan, H. T. Corten, and J. Morrow, and Mr. G. W. Brock contributed many helpful suggestions.

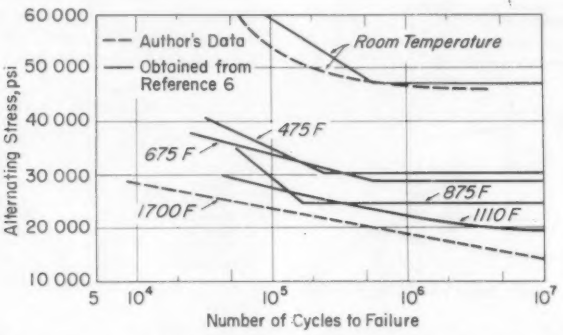

Fig. 11.—*S-N* curve for commercially pure arc-cast molybdenum tested under fully reversed loads.

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Water Permeability Studies on Latex and Latex Paint Films

By ROY C. SIMON

WHILE latex paints have proved quite successful in interior application and exterior applications over masonry-type substrates, latex paints over exterior wood developed film integrity failure within the first one or two years of weathering. Extensive testing to determine the causes of failure has been conducted, and latex paints have been designed to meet the needs revealed by the testing program. Successful latex paints for exterior wood applications are now possible.

Our purpose is to discuss the testing program that helped in the design of these newer paints. Exposures over new wood and over oil-base house-paint primers showed that the start of latex paint film failure and the extent of failure relate to the type of graining in the wood, to the type of wood, and to the type of latex system. Failure over new wood (types of wood normally encountered in home construction) developed with all types of latex systems. Failure over oil-base primers was variable, depending on polymer type. Latex polymers with excellent adhesion to the oil-based primer and with good resistance to weathering provided very durable top

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ROY C. SIMON received his B.A. in Education from North Dakota State College in 1949 and a B.S. in Chemistry in 1952, majoring in paint chemistry. Since 1952 he has been employed by the Dow Chemical Co. in Coatings Technical Service.

coat paints. However, these same top coats applied directly to wood show early breakdown of the surface of the wood as evidenced by grain-line cracking and delamination of the layers of wood in flat-grain areas. Adhesion and flexibility of the latex paint film remain good, so the main causes for failure seemed to be dimensional changes and other effects due to the rapid fluctuation of the moisture content in the surface of the wood. A testing program was set up to evaluate these factors and to find a means of measuring the degree of protection which various latex systems would provide to help in the development of a successful latex system for wood.

Various latex paints and an oil paint system were applied to different panels, some of which then were exposed at 45-deg south and some in a Weather-Ometer. These latter were subjected to various periods of water spray but without light. Following a prolonged rain (for the exposed panels), weight change was tabulated. A nearly 8-hr water-spray cycle in the weather unit was needed to approximate the weight gain of the exterior exposed panels. There were marked differences in weight gain among the latex-painted panels and between them and the oil-painted panels. Figure 1(*a*) shows the weight fluctuations in this cycling test.

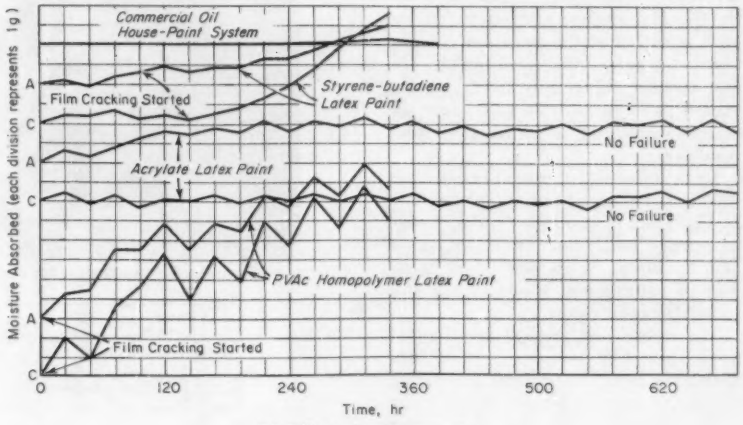
The wet cycle was 8-hr exposure to water spray alone in an Atlas XW-type weather unit. The dry cycle was 16 hr long with continuous light and 9 min of spray in every hour. The panels were weighed just before the water spray periods.

Various clear latex and latex primer films were also applied to wood panels and coated with a conventional 30 per cent poly(vinyl chloride) (PVC) latex top coat system. The same wet-dry cycling test was carried out and weight fluctuations obtained. The results are shown in Fig. 1(*b*).

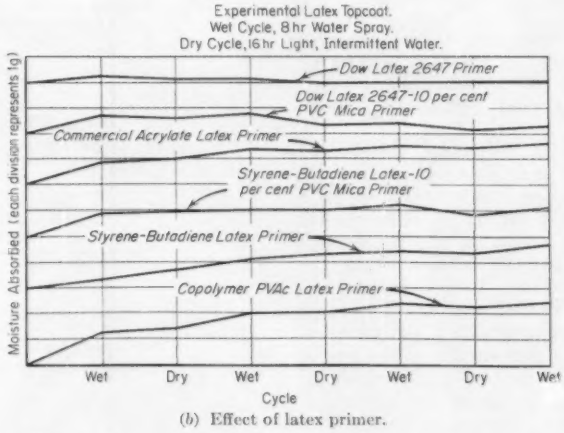
Different latex polymer systems affected weight fluctuation markedly. Attempts were made to measure this by a quantitative test on the film. All polymer systems showed greater fluctuation than did the oil-paint controls. Measurements were made of the moisture permeability of various paint and latex films by using the conventional vapor permeability cup test, with water in the cup. This investigation has shown that pigmentation of Dow latex 2647 films will decrease vapor permeability, particularly with the low 10 per cent PVC primer as shown in Fig. 2.

There is little correlation between the results of this test and the degree of protection provided a wood substrate against the effects of rapid fluctuations in moisture content during wet-dry periods. The acrylic system provided greater protection and had three times the vapor permeability of the styrene-butadiene system. Yet, styrene-butadiene latexes are in the same vapor permeability range as the oil primer. Poly(vinyl acetate) (PVAc) systems have vapor permeability similar to that of the acrylics, but have considerably greater gain and loss of weight during the wet and dry cycles. The relation between vapor permeability of a film and moisture absorption through a film is so slight that some other test approach is necessary to measure these as separate properties.

Several methods for determining moisture permeability through paint



(*a*) Effect of paint system



(*b*) Effect of latex primer.

Fig. 1.—Moisture absorption in flat-grain red cedar panels.

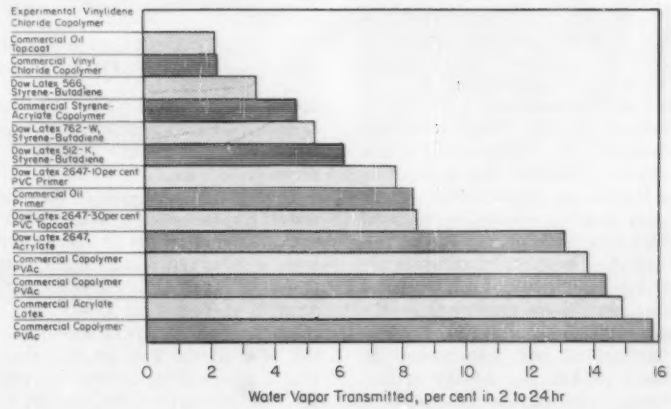


Fig. 2.—Water vapor transmission of various latex and paint films (100 to 50 per cent relative humidity).

and latex films do so by measurement of liquid water permeation. The first method is similar to that used to evaluate liquid-water permeability of oil-paint films. Cobaltous chloride in methocel solution is cast into a glass plate and dried. A film of the test paint is then applied.

With oil paints, time for curing and drying is given, and then moisture permeability is checked by placing water on the film surface and observing the time lapse before the cobaltous chloride changes color. With latex paints, the test method differs only by drying the coated panel in an oven to be sure the cobaltous chloride is in an anhydrous condition.

Little difference in rate of penetration is shown by variations in formulation and polymer in this test. Color change is equally influenced by water vapor and by liquid water, and there is no way of determining which of the two causes the color change.

The second test method investigated used inverted vapor permeability measuring cups. In this test, the coated membrane faces inside, the liquid water is in contact with the film being measured, and rate of weight loss is measured. Results were similar to those obtained in the vapor permeability test method. Again, there was no assured way of differentiating between liquid and vapor permeation through the film.

The third technique investigated was based on an electrical conductivity test. A transformer is used to supply a constant 6-v source. A series resistor holds the maximum current through a 5 per cent salt solution to approximately 250 ma. Carbon rods used in an Atlas Fade-Ometer are dip coated in the latex to provide a film for measurement of permeability. The coated rod is then used as one electrode to complete a circuit in the conducting salt solution. Because conductivity is shown only by a complete liquid bridge through the test film and could not be affected by the vapor permeability of the film, it is felt that this method of test measures rate and extent of permeation of liquid moisture only.

Marked differences were picked up by this method of test. These correlated very well with the differences in weight fluctuation of similar films and paints during wet-dry exposure cycling. There were two major problems encountered with this test method: (1) It was difficult to get uniform coating thicknesses with different latex and paint systems, and (2) air entrapped in the carbon rods formed bubbles in the films. The method of test was revised as illustrated in Fig. 3. In the revised test method, drawdowns are made on tin-plate panels using either a wire-wound rod or a casting bar to assure an approximate 1-mil film thickness. Coated panels can be dried as desired and subjected to the exposure conditions.

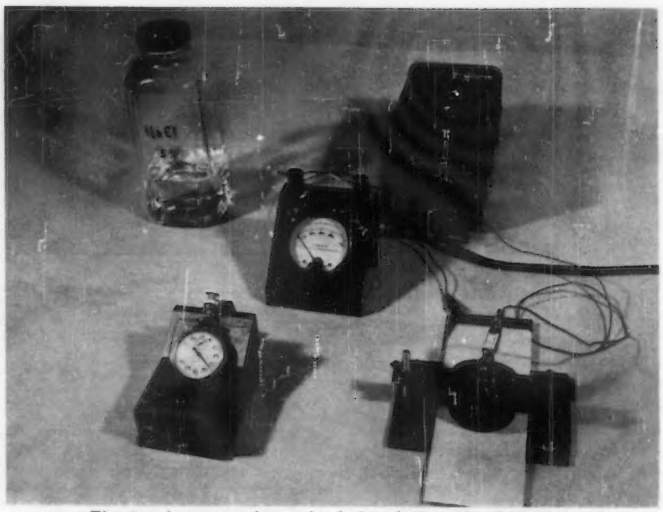
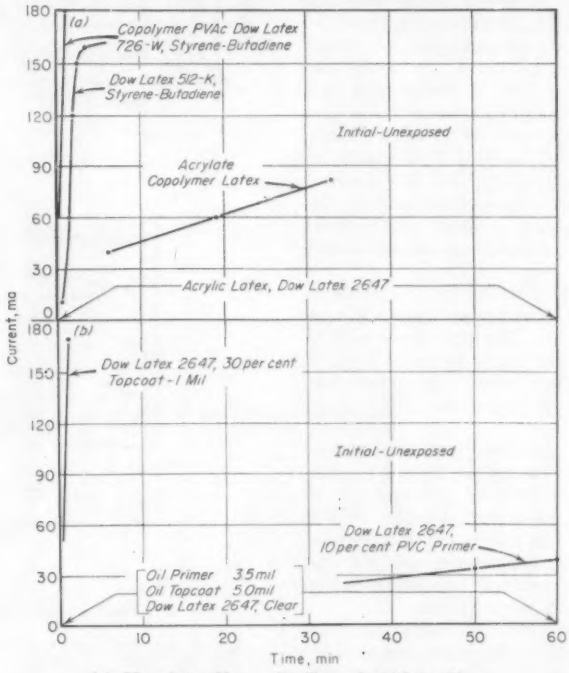


Fig. 3.—Apparatus for revised electrical conductivity test.



(*a*) Clear latex films. (*b*) Formulated latex film.

Fig. 4.—Liquid permeability test results.

During the evaluation for liquid-water transmission, a plastic cylinder with a rubber gasket to ensure a good seal is clamped against the coated panel surface. The conducting salt solution is placed in this cylinder to complete the electrical circuit across the test film. The precise time at which conductivity starts, as well as the rate of conductivity, can be found by observation of the ammeter.

Results obtained with a series of clear latex films of different polymer compositions are shown in Fig. 4(*a*). Variations range from immediate conductivity at the maximum rate for some PVAc and styrene-butadiene films to no conductivity—for a week—for the Dow latex 2647 films. The conductivity measurements vary with films of the same polymer type.

Figure 4(*b*) shows the effects of formulation on Dow latex 2647 which had zero permeability as a clear film. A normal paint formulation incorporating pigment dispersions, protective colloids, antifoamers, and preservatives at a 30 per cent PVC level opened up

the film, and immediate maximum conductivity was shown. Pigmentation to a lower PVC level, at 10 per cent with a mica pigment, showed very slow gradual permeation of liquid moisture through the film.

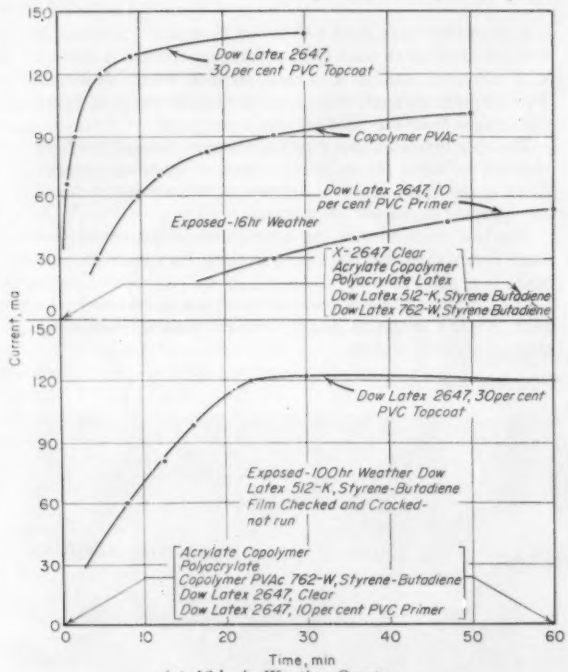
Figures 5(*a*) and (*b*) show the effect of exposure on several types of polymer systems shown in Fig. 4(*a*), as well as on the formulated paints shown in Fig. 4(*b*). In all exposures, the combined effects of ultraviolet light and water lowered the rate of liquid permeability.

In some systems that are affected by ultraviolet light, the rate of lowering is very marked in a short 16-hr exposure period. In other systems, the effect is relatively slow, although exposures over 100-hr duration invariably give noticeable lowering.

Exposure tests on systems combining a nonpermeable latex primer (as shown by the electrical conductivity test) and a normal latex exterior paint top coat have given the following results:

1. Protection of the wood substrate by Dow latex 2647 primer and top coat systems approximated that given by an oil primer-latex top coat system and is markedly improved over that given by a pigmented latex top coat system (30 to 35 PVC) alone.

2. A nonpermeable latex primer system effectively seals off, both initially and after weathering, the water-soluble staining components present in red cedar, redwood, and cedar shakes.


Dow Latex 2647, 30 per cent PVC Topcoat
Copolymer PVAc
Dow Latex 2647, 10 per cent PVC Primer
Exposed-16hr Weather
X-2647 Clear Acrylate Copolymer Polyacrylate Latex
Dow Latex 512-K, Styrene Butadiene
Dow Latex 762-W, Styrene Butadiene
Current, ma
Dow Latex 2647, 30per cent PVC Topcoat
Exposed-100hr Weather Dow Latex 512-K, Styrene-Butadiene Film Checked and Cracked-not run
Acrylate Copolymer Polyacrylate Copolymer PVAc 762-W, Styrene-Butadiene
Dow Latex 2647, Clear
Dow Latex 2647, 10per cent PVC Primer
Time, min

(*a*) 16 hr in Weather-Ometer.
(*b*) 100 hr in Weather-Ometer.

Fig. 5.—Effects of exposure on moisture permeability.

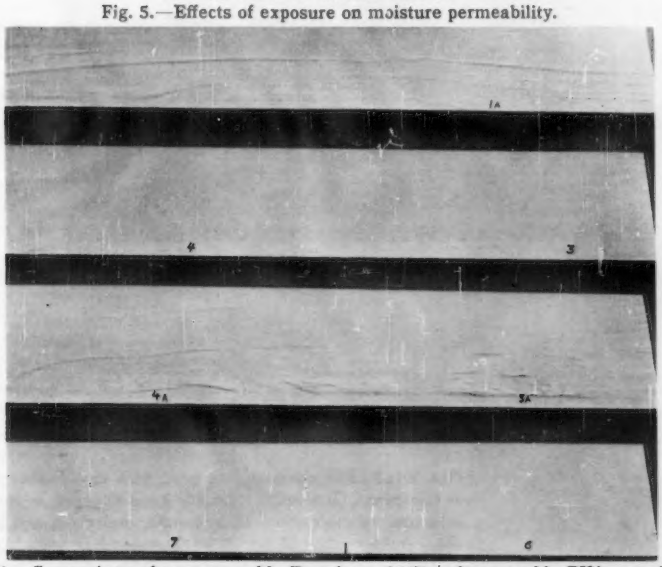


Fig. 6.—Comparison of nonpermeable Dow latex 2647 and permeable PVAc copolymer system.

Comparisons are shown in Fig. 6 between paints made with nonpermeable Dow latex 2647 and a very permeable PVAc copolymer system. A 30 per cent PVC top coat is applied on the right side directly to edge- and flat-grain red cedar siding. On the center or left area, the same top coat is applied over a clear film of the latex that was used in the top coat paint. Both systems look good over edge-grain wood after $2\frac{1}{2}$ yr exposure at vertical south in Michigan. The difference in the protection afforded by the latex system is apparent in the applications over flat-grain panels.

The conductivity test method also is useful in determining the extent of protection from liquid water that might be expected of latex systems applied over metal. These industrial- and maintenance-type latex coatings are now commercially significant, and their resistance to liquid water is an important aspect of their behavior.

Because of the many polymer types of latexes, and because different polymerization techniques produce many variables within a given polymer type, latex properties are impossible to predict, save through accurate test procedure. Accurate testing is particularly necessary to permit profiling the vapor permeability and liquid water permeability of latex films.

The conductivity test method is an accurate means of distinguishing between liquid water permeability and vapor permeability of latex films. It is adaptable to the accurate measurement of the effects of formulation and exposure on those same properties. The test method may prove to be an important tool to paint formulators in helping them predict the behavior of latex paints over wood and over metal.

Addendum

Recent revisions of the test procedure include use of a 0.5 per cent salt solution as the conducting liquid instead of the 5 per cent concentration. Maximum current is lower, but start of conduction and rate of buildup are similar. This change minimizes a possible influence of higher salt concentrations on test results. In a second revision, a recorder is used to plot conductivity versus time, thereby eliminating the need for direct observation during the test.

Determination of the Thermal Stability of Disiloxane-Base Hydraulic Fluids

By MYRA WILLARD

A disiloxane-base fluid was tested for thermal stability at 400 and 450 F in an open glass apparatus continually flushed with nitrogen, and in a sealed stainless-steel apparatus. Two different methods were used to remove traces of water and oxygen from the fluid prior to heat aging.

The data indicated that flushing nitrogen through the fluid was not sufficient for removing traces of water and oxygen found in the fluid; however, the use of vacuum and preheating appeared to remove these traces.

The test conducted in the stainless-steel apparatus was more severe than that conducted in the glass apparatus, particularly at 450 F.

The presence of trace amounts of oxygen and water in the fluid induced oxidation and hydrolysis yielding misleading thermal stability results.

THE EFFICIENT performance demanded by high-speed aircraft of hydraulic systems at elevated temperature has led to the formulation of new and unfamiliar fluids. Proper application of these fluids requires extensive examination of their properties, among the most important of which is thermal stability.

There is no standard test for thermal stability of hydraulic fluids. Special considerations such as test temperature, duration of test, susceptibility of the fluid to trace quantities of oxygen and water, material for and design of test apparatus, choice of proper characteristics by which to evaluate degradation, and reproducibility and repeatability of the test make the writing of a standard test difficult. The isoteniscope method, which provides for determination of an empirical decomposition point, does not give information about the rate of thermal breakdown or the severity of thermal effects below the decomposition point (1,2).[1] A test method generally used is the sealed tube method or a variation of that method. Such a method has been adapted in the British DERD 2487 thermal stability test (3). The major disadvantage of this method is the possibility of misleading results due to oxidation and hydrolysis of the test fluid by entrained oxygen and water. The test depends on passage of a nitrogen stream through the test assembly for 20 min for removal of these contaminants.

A sealed-tube test method adopted by Gulf Research and Development Co. provides for deaeration of the fluid before charging the test cell (4), but the subsequent introduction of the fluid to the test assembly by means of a sintered glass filter leads to possible reabsorption of oxygen and water.

In the evaluation of the thermal stability of a disiloxane-base fluid at 400 and 450 F undertaken at Hughes Air-

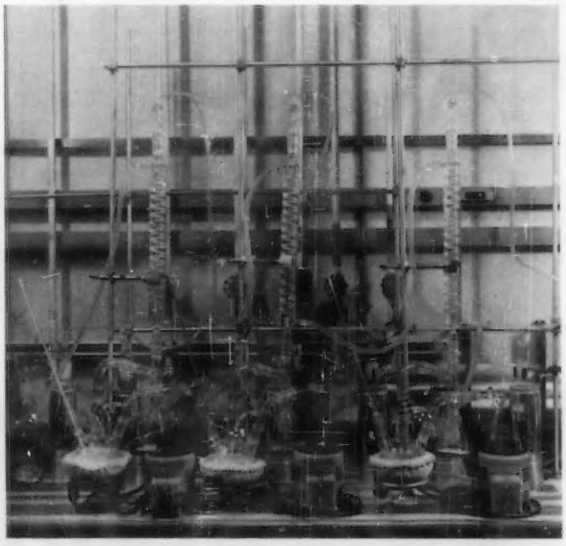


Fig. 1.—Multiple glass apparatus used in conducting thermal stability studies.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

MYRA WILLARD, chemist, has been with the Hughes Aircraft Company since 1957. She has been engaged in extensive laboratory evaluations of hydraulic, dielectric, and heat transfer fluids. One of her chief interests has been in the investigation of fluid thermal stability. Mrs. Willard graduated from Immaculate Heart College, Los Angeles, Calif.

craft Co., a test method was devised in which all oxygen and water were excluded from contact with the fluid. The effect on the test results of the type of test apparatus used and of the presence of small amounts of oxygen and water were investigated.

Test Procedures

Phase I—Thermal Stability Studies

Two types of apparatus were used. The first, an all-glass apparatus, shown in Figs. 1 and 2, consisted of a three-necked, 500-ml flask (*1*), fitted with a heating mantle (*2*), whose output was controlled by a powerstat (*3*). Into the side necks of the flask were inserted a thermometer (*4*), and a nitrogen inlet and vacuum connector (*5*). Into the center neck was inserted a 75-deg angle tube (*6*), which connected a water-cooled Graham condenser (*7*) to the system, but which at the same time prevented volatile materials, carried by the nitrogen stream during pretreatment and during aging, from returning to the sample through condensation. Three traps (*8, 9, 10*) connected to the reflux condenser were provided to collect the volatile decomposition products at room temperature (77 F), 32 F, and −110 F, respectively.

The second apparatus, pictured in Fig. 3, constructed of type 303 stainless steel, was used to determine the stability of the fluid in contact with material similar to that in the actual operating system. The apparatus consisted of bombs (*1*), set in a thermostatically controlled heating block (*2*), and connected to a manifold (*3*), which was used both for subjecting the system to a vacuum and as a nitrogen inlet.

Two methods of pretreatment were attempted to remove all traces of oxygen and water before heat aging.

1. Water pump nitrogen, dried by passing through magnesium perchlorate desiccant, was bubbled through the fluid sample in the test assembly heated to 200 F for at least 2 hr. In cases where samples were taken from previously opened containers the pretreatment was continued for 24 hr. With continuous nitrogen bubbling at the rate of 3 bubbles per sec the temperature was raised over a 1-hr period to the test temperature.

2. The fluid sample was subjected to a vacuum of approximately 1 mm Hg for 30 min at room temperature, and for an additional 30 min at 125 F. Dry nitrogen was bled into the system for pressure equalization, bubbled through the sample for 1 hr, and with continuous nitrogen bubbling, the temperature was raised over a 1-hr period to the test temperature.

Samples of the fluid (200 ml each) were exposed to 400 and 450 F under nitrogen atmospheres in 24-hr increments up to 305 hr or until deterioration equal to a change in viscosity of greater than 30 per cent occurred. Nitrogen was continually bubbled through the test sample in the glass apparatus. Since the stainless-steel bombs could be sealed, no nitrogen was bubbled through those samples during the aging period.

Phase II—Effect of Air and Water on Stability at 450 F

Phase II was an investigation of the effect on the stability of the fluid of the presence of maximum quantities of oxygen and water assimilated from contact with air—approximately 46 ppm of oxy-

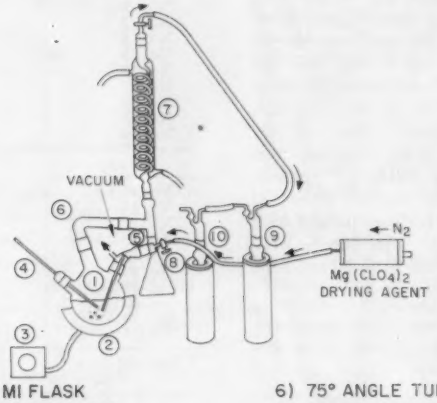


Fig. 2—Glass thermal stability test apparatus.

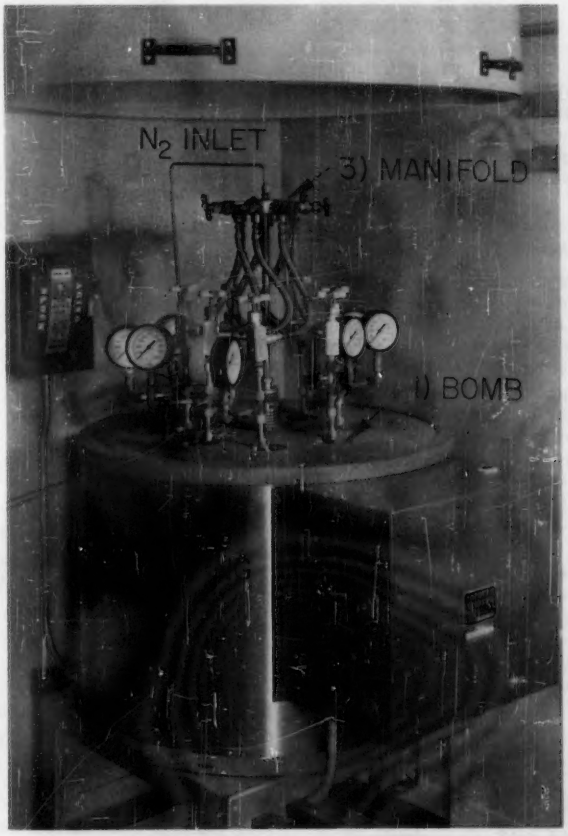


Fig. 3.—Stainless-steel aging block.

gen (3.4 cu cm per 100 g of fluid) and 250 ppm of water. The rate of deterioration produced by the presence of a small amount of undissolved water was also studied.

The stainless-steel apparatus was used for these studies. Samples of fluid (200 ml) were saturated with air and water by bubbling humid air through the samples for 4 hr. One group of samples was placed in the stainless-steel bombs, the surfaces purged with the nitrogen for 3 min, and the bombs sealed and heated at 450 F in 24-hr increments up to 96 hr. To each specimen of a second group of air-water saturated fluid samples was added 1 per cent water by volume. These samples were shaken, placed in the bombs, and the surfaces purged with nitrogen for 3 min. The bombs were sealed and aged at 450 F for 24 to 72 hr.

Test Methods

The methods used to measure the rate and magnitude of fluid deterioration are listed below:

Property	*Method*
Viscosity	ASTM Method of Test for Saybolt Viscosity (D 88–56).[2]
Flash point	ASTM Method of Test for Flash and Fire Points by Cleveland Open Cup (D 92–57).[3]

Infrared spectra of exposed samples and decomposition products collected in the cold traps were prepared using a Perkin-Elmer Model 21 infrared spectrophotometer employing a sodium-chloride prism.

Results

Phase I—Thermal Stability Studies

Fluid deterioration was measured chiefly by changes in viscosity. Flash point was used as a second criterion. The change in viscosity during thermal stress results chiefly from a breakdown of the silicone thickener (5). A decrease in flash point is indicative of hydrolysis and oxygen-catalyzed decomposition of the disiloxane base with the production of a flammable alcohol (6).

Examination of the data obtained at both 400 F (Table I) and 450 F (Table II) showed that the two methods used for pretreating the fluid before aging were not similarly effective. Simply flushing nitrogen through the fluid apparently did not remove all of the dissolved air or water, as evidenced by the large decreases in viscosity and flash point of the exposed fluid pretreated in this manner. This effect was more noticeable in the tests at 400 F.

[2] 1958 Book of ASTM Standards, Part 4, p. 1059; Part 7, p. 19.
[3] *Ibid.*, Part 4, p. 980; Part 7, p. 30.

TABLE I.—VISCOSITY AND FLASH POINT OF DISILOXANE-BASE HYDRAULIC FLUID AGED AT 400 F IN A NITROGEN ATMOSPHERE.

Sample	Pretreatment[a]	Conditions of Test, hr	Viscosity at 210 F, centistokes	Viscosity Change, per cent[b]	Flash Point, deg Fahr	Change in Flash Point, per cent[b]
No. 1		Unexposed	11.8	...	410	...
Glass Apparatus						
No. 2	2	24	11.9	+1.0	400	−2.0
No. 3	2	48	11.6	−2.0	370	−10.0
No. 4	2	72	11.5	−2.5	370	−10.0
No. 5	2	96	12.0	+2.0	425	+3.5
No. 6	2	120	12.0	+2.0	375	−8.5
No. 7	2	144	11.4	−3.5	345	−16.0
No. 8	2	168	11.9	+1.0	350	−14.0
No. 9	2	192	11.9	+1.0	400	−2.0
No. 10	2	214	11.4	−3.5	390	−5.0
No. 11	2	240	11.5	−2.5	375	−8.5
No. 12	2	260	12.5	+6.0	415	+1.0
No. 13	2	287	12.0	+2.0	410	0.0
No. 14	2	305	12.2	+3.5	415	+2.0
Stainless-Steel Apparatus						
No. 15	1	24	11.6	−2.0	390	−5.0
No. 16	1	48	10.6	−10.0	370	−10.0
No. 17	2	48	11.0	−7.0	350	−14.0
No. 18	1	72	10.5	−11.0	400	−2.0
No. 19	1	96	9.7	−18.0	400	−2.0
No. 20	2	96	11.0	−7.0	395	−3.7
No. 21	1	120	10.0	−15.0	405	−1.0
No. 22	1	144	9.6	−18.5	345	−16.0
No. 23	1	168	9.2	−22.0	310	−24.0
No. 24	1	192	8.2	−29.0	390	−5.0

[a] Pretreatment:
1. Nitrogen bubbling through fluid for at least 2 hr.
2. Vacuum 30 min at room temperature and for an additional 30 min at 125 F, followed by nitrogen bubbling for 1 hr.

[b] Per cent change in viscosity and flash point were based on 11.8 centistokes and 410 F for the unexposed fluid. The values for the unexposed fluid actually ranged from viscosities of 11.6 to 11.8 centistokes and flash points of 400 to 420 F.

TABLE II.—VISCOSITY AND FLASH POINT OF DISILOXANE BASE HYDRAULIC FLUID AGED AT 450 F IN A NITROGEN ATMOSPHERE.

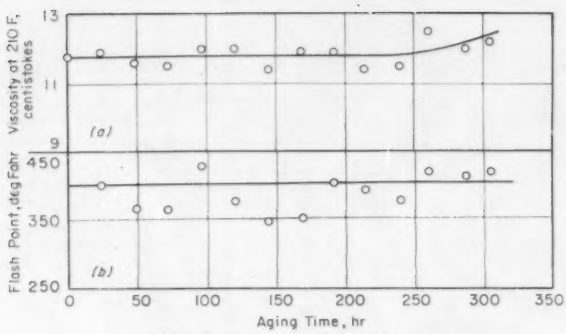
Sample	Pretreatment[a]	Conditions of Test, hr	Viscosity at 210 F, centistokes	Viscosity Change, per cent[b]	Flash Point, deg Fahr	Change in Flash Point, per cent[b]	Remarks
No. 1	Unexposed		11.8	...	410	...	
Glass Apparatus							
No. 25	2	24	10.8	−8.5	370	−10	
No. 26	2	48	11.1	−6.0	375	−8.5	
No. 27	2	72	11.1	−6.0	410	0.0	
No. 28	2	96	11.5	−2.5	395	−3.5	
No. 29	2	120	10.6	−10.0	405	−1.0	
No. 30	2	144	8.8	−25.5	400	−2.0	
No. 31	2	168	7.3	−38.0	410	0.0	
No. 32	1	100	5.4	−54.2	...	...	Sample taken from fluid can opened 3 months previously.
No. 33	1	100	6.7	−43.2	...	...	Sample taken from fluid can opened 1 month previously.
Stainless-Steel Apparatus							
No. 34	1	24	8.9	−24.5	370	−10	Fluid stored under air until sampled.
No. 35	1	48	8.0	−32.0	360	−12	
No. 36	1	72	6.3	−46.5	320	−22	
No. 37	1	96	5.9	−50.0	285	−31	
No. 38	1	24	10.7	−9.0	395	−3.5	Fluid stored under nitrogen until sampled.
No. 39	1	48	10.3	−13.0	415	+1.0	
No. 40	1	70	9.6	−18.6	420	+2.0	
No. 41	1	96	10.2	−13.6	415	+1.0	
No. 42	2	96	9.7	−17.8	385	−6.1	
No. 43	2	48	10.4	−12.0	420	+2.0	

[a] Pretreatment:
1. Nitrogen bubbling through fluid for at least 2 hr.
2. Vacuum 30 min at room temperature and for an additional 30 min at 125 F, followed by nitrogen bubbling for 1 hr.

[b] Per cent change in viscosity and flash point were based on 11.8 centistokes and 410 F for the unexposed fluid. The values of the unexposed fluid actually ranged from viscosities of 11.6 to 11.8 centistokes and flash points of 400 to 420 F.

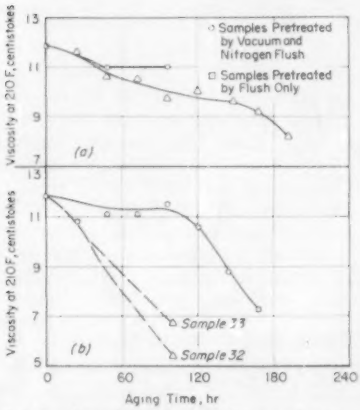
In the glass apparatus, vacuum-treated fluid aged to 305 hr at 400 F suffered no appreciable degradation except as noted in the flash points of those samples aged for 48, 72, 144, and 168 hr (Fig. 4). The decrease in flash point in these cases is believed to have been caused by incomplete removal of water from the nitrogen, substantiated by the fact that replacement of the inefficient desiccant permitted the flash point to return to normal in subsequently aged samples.

Though the conditions of aging in the stainless-steel bombs were modified by fluid-metal contact and by metal-



(*a*) Viscosity. (*b*) Flash point.

Fig. 4.—Disiloxane-base hydraulic fluid aged at 400 F in glass apparatus.



(*a*) Aged at 400 F in stainless-steel apparatus.
(*b*) Aged at 450 F in glass apparatus.

Fig. 5.—Viscosity of disiloxane-base hydraulic fluid.

surface-occluded oxygen and were less controlled than in the glass apparatus, the effect of pretreatment still appeared, but to a lesser extent (Fig. 5(*a*)). The vacuum-treated sample exhibited a viscosity decrease of 7 per cent and the nitrogen-flushed sample 18 per cent after 96 hr aging at 400 F.

The effect of pretreatment is also apparent in the exposures of the fluid at 450 F in the glass apparatus (Fig. 5(*b*)). Samples 32 and 33, taken from containers originally opened 3 months and 1 month prior to testing, respectively, and pretreated by means of nitrogen flushing through the fluid 24 hr instead of 2 hr, exhibited after 100 hr aging viscosity losses 52 per cent and 41 per cent greater than the samples that had been vacuum treated. The flash points of these samples were not measured; however, formation of alcohol was established by infrared spectroanalysis (Figs. 6 and 7). The alcohol was identified as 2-ethylbutanol-1 (Figs. 8 and 9).

As seen in samples aged in the stainless-steel apparatus (Fig. 10 and Table II), the length of time the fluid remained in contact with the air before testing affected its stability, because the efficiency of nitrogen bubbling in removing dissolved air and water was limited. Nitrogen flushing was the pretreatment employed in every case. However, the fluid taken from a batch stored under air exhibited a 24.5 per cent decrease in viscosity after a mere 24-hr exposure to 450 F, and a 50 per cent decrease after 96 hr; at the same time, the flash point decreased 31 per cent. On the other hand, fluid taken from a batch stored under nitrogen showed only a 13.6 per cent decrease in viscosity and no change in flash point after 96-hr exposure to 450 F. Flash point data for these cases suggest that water as well as oxygen was responsible for the rapid deterioration of the former samples.

While large differences in fluid stability were evident as a result of the two storage conditions, no such difference in stability was noted at 450 F when the fluid stored under nitrogen prior to sampling was pretreated by both procedures (Fig. 11). The effects of storage conditions, pretreatment, and apparatus are summarized below and in Table III:

1. With storage under nitrogen and pretreatment by vacuum, tests carried

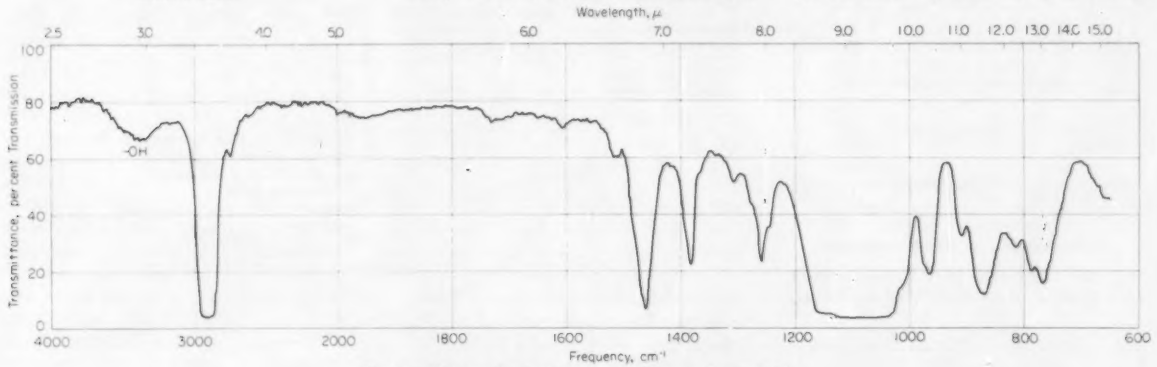


Fig. 6.—Infrared spectrum of disiloxane-base fluid.

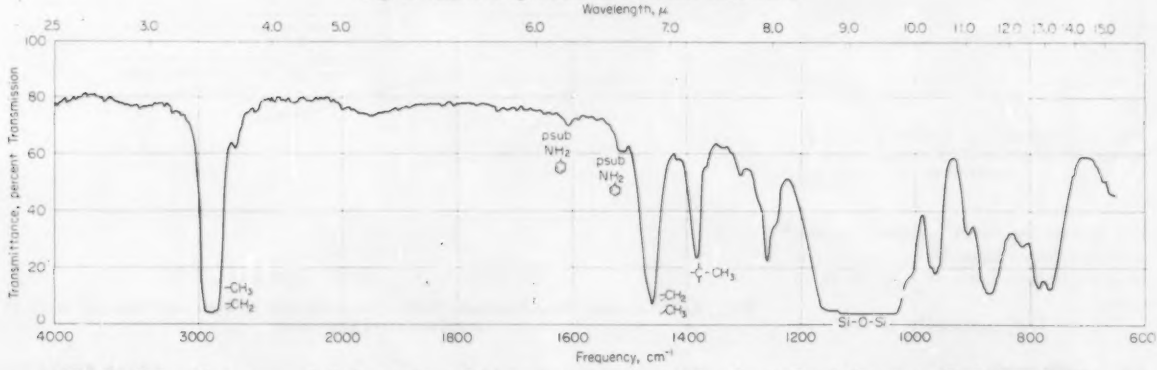


Fig. 7.—Infrared spectrum of disiloxane-base fluid aged at 450 F for 100 hr after 24 hr of nitrogen preflush (sample 32).

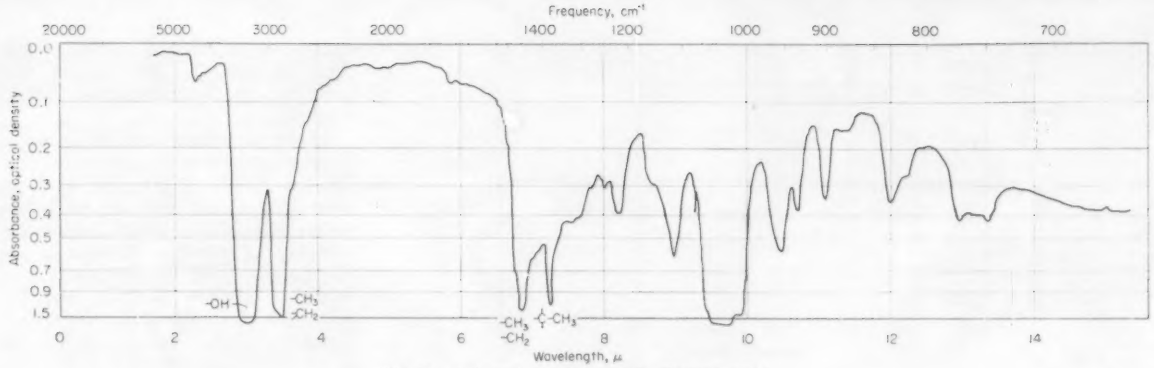


Fig. 8.—Infrared spectrum of 2-ethylbutanol-1.

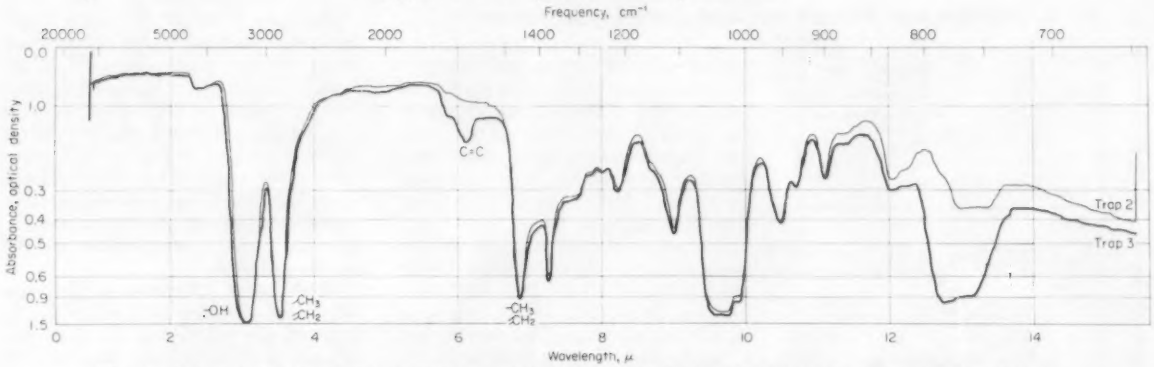
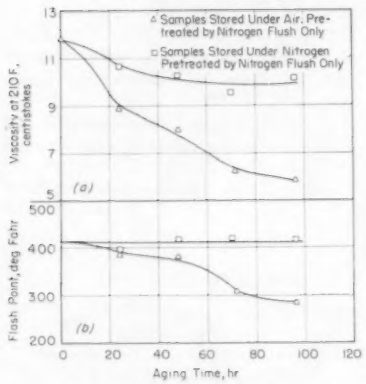


Fig. 9.—Infrared spectra of volatile products of disiloxane-base fluid collected during aging at 400 and 450 F.



(*a*) Viscosity. (*b*) Flash point.

Fig. 10.—Disiloxane-base hydraulic fluid aged at 450 F in stainless-steel apparatus.

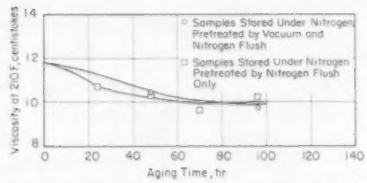


Fig. 11.—Viscosity of disiloxane-base hydraulic fluid aged at 450 F in stainless-steel apparatus.

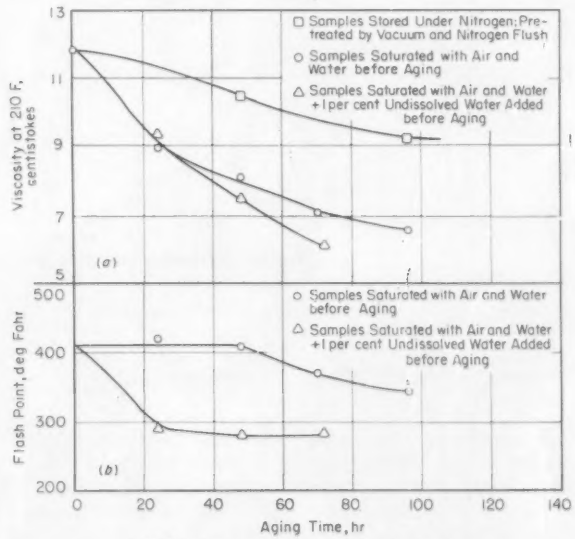
out in stainless steel produced greater viscosity losses than those carried out in glass during both 48 and 96 hr of aging.

NOTE: The apparently greater vis-

TABLE III.—STABILITY OF DISILOXANE-BASE HYDRAULIC FLUID EXPOSED TO SEVERAL TEST CONDITIONS AT 450 F.

	48-hr Exposure				96-hr Exposure				
Sample No.	26	43	39	35	28	42	41	37	33[a]
Storage conditions	Nitrogen	Nitrogen	Nitrogen	Air	Nitrogen	Nitrogen	Nitrogen	Air	Air
Test apparatus	Glass	SS[b]	SS[b]	SS[b]	Glass	SS[b]	SS[b]	SS[b]	Glass
Pretreatment	Vacuum	Vacuum	N_2 Flush	N_2 Flush	Vacuum	Vacuum	N_2 Flush	N_2 Flush	N_2 Flush
Viscosity loss, per cent	6	12	13	32	2.5	17.8	13.6	50	43.2

[a] Exposed 100 hr.
[b] Stainless steel.



(*a*) Viscosity. (*b*) Flash point.

Fig. 12.—Disiloxane-base hydraulic fluid aged in contact with air and water at 450 F in stainless-steel apparatus.

TABLE IV.—VISCOSITY AND FLASH POINT OF DISILOXANE-BASE HYDRAULIC FLUID AGED AT 450 F IN THE PRESENCE OF OXYGEN AND WATER.

Sample	Pre-treatment[a]	Conditions of test, hr	Viscosity at 210 F, centistokes	Viscosity Change, per cent[b]	Flash Point, deg Fahr	Change in Flash Point, per cent[b]
No. 1		Unexposed	11.8	...	410	...
		STAINLESS-STEEL APPARATUS				
No. 44	3	24	8.9	−24.5	420	+2.0
No. 45	3	48	8.1	−31.5	410	0.0
No. 46	3	70	7.1	−40.0	370	−10.0
No. 47	3	96	6.6	−44.0	345	−15.8
No. 48	4	24	9.3	−21.0	290	−29.5
No. 49	4	48	7.5	−36.5	280	−31.5
No. 50	4	72	6.1	−48.0	285	−30.5

[a] Pretreatment:
3. Fluid saturated with air and water.
4. Fluid saturated with air and water plus 1 per cent gross water added.

[b] Per cent change in viscosity and flash point were based on 11.8 centistokes and 410 F for the unexposed fluid. The values of the unexposed fluid actually ranged from viscosities of 11.6 to 11.8 centistokes and flash points of 400 to 420 F.

cosity loss exhibited by sample 26 over sample 28 was due, as explained before, to a small contamination of the nitrogen stream with water during aging of sample 26.

2. When the fluid had been stored under nitrogen prior to sampling, there were little differences in the viscosities of samples aged after pretreatment by vacuum or nitrogen bubbling. This was true after both 48 and 96 hr of exposure.

3. Nitrogen flushing alone was insufficient for removing all of the oxygen and water absorbed by the fluid during storage under air. The oxygen and water remaining in solution caused very large viscosity decreases after both 48 and 96 hr of exposure and in both glass and stainless-steel apparatuses.

Phase II—Effect of Air and Water on Stability at 450 F

The results of heat aging the disiloxane-base fluid saturated with air and water, with and without the presence of 1 per cent excess of water, are illustrated in Fig. 12. Data are presented in Table IV.

These tests illustrate that the presence of undissolved oxygen and water yields misleading thermal stability results. The data show that the fluid saturated with water and air deteriorated rapidly with time at 450 F. After only 24 hr at the test temperature there was a 24.5 per cent decrease in viscosity. An appreciable decrease in flash point

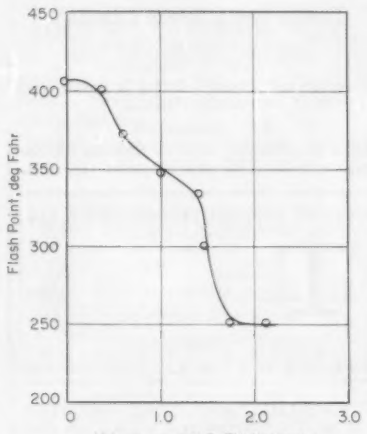


Fig. 13.—Effect of the presence of 2-ethylbutanol-1 on the flash point of disiloxane-base hydraulic fluid.

to 345 F occurred after 96 hr of aging. It was shown that a reduction to this value required the presence of 1.2 per cent 2-ethylbutanol-1 (Fig. 13). Note the similarity of the viscosity and flash-point values to those for the air-stored samples which had been subjected to thermal stability testing after pretreatment by nitrogen flush.

The addition of 1 per cent undissolved water to the fluid caused deterioration to proceed at a faster rate. Formation of alcohol was apparent within 24 hr of exposure.

Conclusions

A 1-hr vacuum treatment followed by nitrogen flushing for 1 hr was more efficient in removing dissolved oxygen and water from the disiloxane-base fluid than flushing with nitrogen for 24 hr. Employing this pretreatment, the use of the stainless-steel apparatus provided a more severe condition for the thermal stability test than did the glass apparatus. In the glass apparatus, little degradation occurred at 450 F for 120 hr, whereas in the stainless-steel apparatus the same amount of degradation occurred within 96 hr. At 400 F the fluid was stable for the duration of the tests in both the glass (305 hr) and the stainless-steel apparatus (96 hr).

The consequence of dissolved oxygen and water on thermal stability results was effectively shown. In the presence of 46 ppm of oxygen and 250 ppm of water, degradation at 450 F began within 24 hr.

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A tip for radiographers

Little white specks have been appearing on radiographs of zirconium alloys. Since one of the principal reasons for radiographing zirconium alloys in the first place is for detection of tiny tungsten inclusions, this is not surprising. What has surprised the radiographers has been that most of the little white specks appear in different places on two successive films of the same part! Or even on two films made of the same part simultaneously!

Upon investigation* it turns out that the phenomenon does not contain enough high science to be worth the exclamation points. The moving specks are dandruff, cigarette ashes, lint, and such rubbish. So help us!

The junk gets picked up when the customer loads the film into the cardboard exposure holders. These often contain lead foils between which the film nestles. Besides serving as a filter to modify radiation quality, the lead emits electrons to intensify the image density. The junk simply casts electron shadows.

So we published a little paper in *Nondestructive Testing*. We said that in this specialized type of radiography for small inclusions it might be well to put cardboard under the front lead screen and use the lead only as a filter. We also advised surgical cleanliness, a darkroom under slight positive air pressure, and no smoking. This supplementary advice isn't really necessary if you don't try to shave exposure time by putting the lead in contact with the film, but it sounds wholesome. Furthermore, this line of thought led to the question of why make the radiographer load the film into a cardboard exposure holder in his own darkroom. Why not do it for him in our surgically clean, slight-positive-air-pressure, no-smoking factory?

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*We needn't have investigated. We could have just dropped off the film, scooped up our money, and run, tarrying only long enough to suggest that 1) two films be routinely made of every part and then compared to distinguish moving white specks from real white specks; and 2) somebody should do a Ph.D. thesis on the effect. Sales would have doubled.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Bookshelf

Laboratory Manual in Soil Mechanics

Second Edition; Raymond F. Dawson; Putman Publishing Corp., New York, N. Y. (1960); 177 pp., Illus.; Data Sheets.

Reviewed by L. C. Gilbert, ASTM Staff.

THE INTEREST and demand for a laboratory manual of this type has led to a second edition of this publication. Originally prepared for the author's laboratory classes in soil mechanics at the University of Texas, the notes have now been prepared for wide usage.

The purpose of these detailed notes is to expand on the procedures found in such standard methods as those published by ASTM and the American Association of State Highway Officials in order to permit the student or inexperienced laboratory assistant to conduct the laboratory experiments without additional instruction. Additional tests not covered in standards are also included in the contents.

Professor Dawson is an active member of long standing on ASTM Committee D-18 on Soils for Engineering Purposes.

Books reviewed here are furnished by publishers knowing of the broad interests of ASTM. Occasionally reviews are prepared by ASTM Staff members, but in most cases, the books are reviewed by Society members or other individuals who are well informed on the subject at hand. Members who wish to be considered for reviewing books are invited to send in their names and the subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered.

Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Highway Engineering Handbook

Edited by K. B. Woods, D. S. Berry, and W. H. Goetz; McGraw-Hill Book Co., Inc., New York, N. Y. (1960); 1696 pp.; Illus.; $25.

Reviewed by L. C. Gilbert, ASTM Staff.

THE NATIONAL HIGHWAY Program, sponsored by the federal government and now well advanced in its development and actual construction, has given greater emphasis than ever to highway engineering. The magnitude of this field of construction is almost beyond imagination in its effect on the national economy. The volume of materials and products, the manpower employed, the improvement of transportation facilities, all adds up to a staggering amount.

The need for a comprehensive handbook on modern highway engineering has been long-standing. The preparation of such a handbook represents a tremendous amount of effort and time in the compilation of engineering data covering the essential features of operation, design, and construction of highways. It is not surprising to note the size of such a handbook now prepared and published under the direction of Prof. Kenneth B. Woods, head, School of Civil Engineering, Purdue University, as editor-in-chief, and his two associate editors: Donald S. Berry, professor of civil engineering, Northwestern University, and William H. Goetz, professor of highway engineering and research engineer, Joint Highway Research Project, Purdue University. The editors have accomplished this task in a com-

(Continued on page 64)

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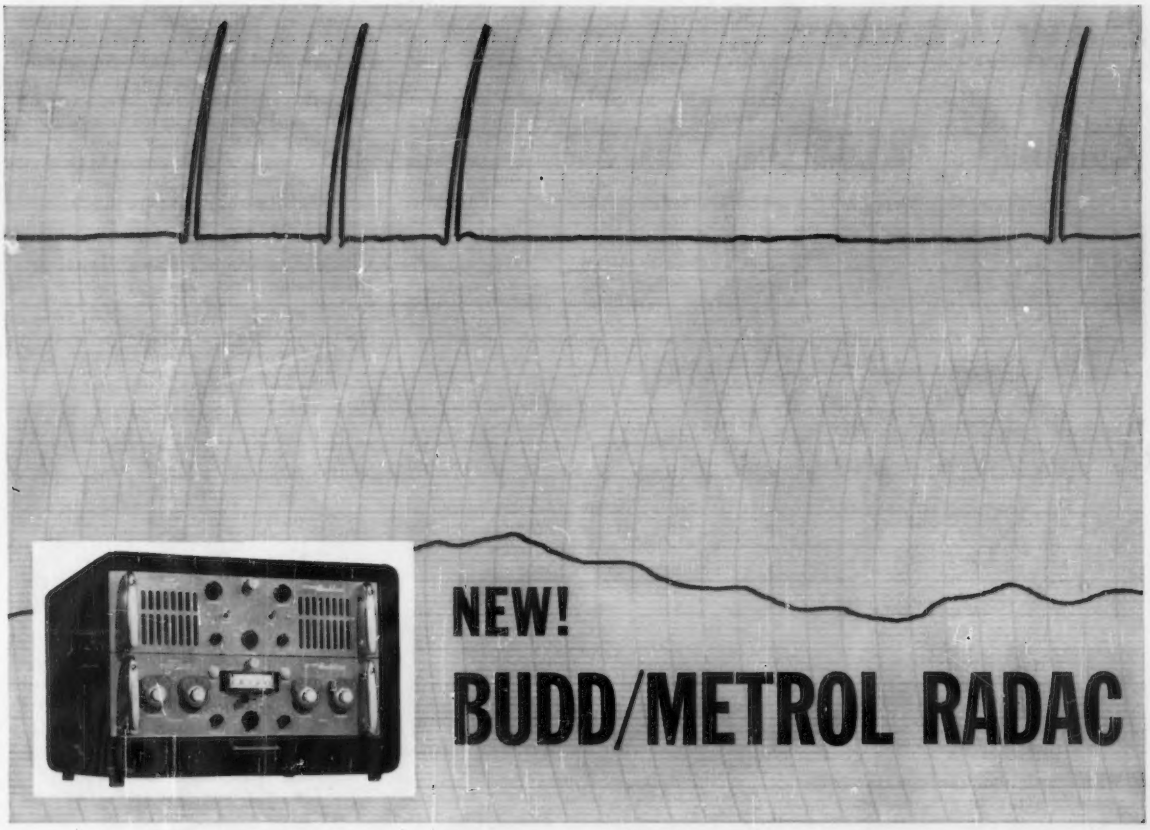

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BOOKSHELF

(*Continued from page 62*)

mendable manner and have developed a book containing all important information.

This handbook has been prepared for practicing highway engineers, highway administrators, consulting engineering firms, materials producers, planners, college faculties, and undergraduate and graduate students in civil engineering.

The four main parts cover administration and finance; engineering characteristics of soils and soil testing; contracts and specifications; and geometric design. There are 28 sections in all, each written by leading specialists.

Special reference should be made to a very extensive section by Professor Woods dealing with the "Distribution of Soils in North America." Much of this is published for the first time, and is based on Professor Woods' extensive studies and widespread travels. Several maps supplement the text.

The book is replete with extensive lists of references. Much of the data has been condensed into useful tables. There is a very detailed subject index—most helpful in a book of this size.

Handbook of Filtration

The Eaton-Dikeman Co., Mount Holly Springs, Pa., (1960); Illus.; $2.50

Reviewed by W. K. Wilson, National Bureau of Standards.

THE AIM OF this book is well described in the Foreword as follows:

"More exacting demands on performance have combined with improved analytical techniques to focus renewed interest upon the filtration process. Theoretical analysis and the application of new tools and methods have broadened understanding of what has become an important aspect of modern science and living. This handbook provides a survey of the latest development of paper filtration and demonstrates how science and technology are contributing even to this ancient art.

"Although many qualities are still described by . . .indefinite terms, . . . broad fundamental research investigations are beginning to disclose quantitatively some of the obscure variables which influence the characteristics of filter paper. For a fuller comprehension of the nature of these variables, this handbook presents a qualitative analysis of the filtration operation."

This book assembles in one place a large amount of information of value to laboratory workers and to individuals with industrial filtration problems. A chapter is devoted to test methods for the evaluation of filter papers. Some of these methods have never been described in the literature. The chapters on retention and permeability are well presented, and contain both practical and theoretical information. The discussion of the relative merits of cotton and wood pulp fibers for making filter papers is especially interesting. The section on industrial filtration includes an excellent elementary description of the operation of the filter press.

The book is well arranged and attractively bound. The authors emphasize that it is subject to periodic revision and expansion.

BRAB Reports to Federal Housing Administration

Prepared and edited by Staff, Building Research Advisory Board, National Academy of Sciences–National Research Council, Washington, D. C.

Adapted from publisher's description.

A SERIES OF reports published by the Building Research Advisory Board provide very interesting and informative reading to those concerned with building construction and maintenance. The result of technical studies conducted for the Federal Housing Administration, the reports represent the voluntary efforts of highly qualified individuals in the field of building technology.

Several of these reports are listed below, representing a portion of the entire group of reports published to date and available to those interested. These are:

Design Criteria for Residential Slabs-on-Ground; Publication 657; $2.00.

The Use of Grade Boards in Individual Household Absorption Field Trenches; Publication 506; $1.50.

Effectiveness of Concrete Admixtures in Controlling Transmission of Moisture Through Slabs-on-Ground; Publication 596; $1.50.

Underground Heat Distribution Systems; Publication 660; no price noted.

Selection and Maintenance of Air Filters; Publication 703; $1.50.

Protection from Moisture for Slab-on-Ground Construction and Habitable Spaces Below Grade; Publication 707; $1.50.

Noncrystalline Solids

Edited by V. D. Frechette; John Wiley & Sons, Inc., New York, N. Y. (June, 1960); 536 pp.; $15.

Adapted from publisher's description.

AN INFORMATION EXCHANGE of some moment took place in September, 1958, when a small group of scientists gathered at Alfred, N. Y. to talk to each other about their research in noncrystalline solids. The conference was jointly sponsored by the National Academy of Sciences–National Research Council, Committee on Solids, and the Air Force Office of Scientific Research, and is the fourth such conference so sponsored. Previous conferences covered Phase Transformations in Solids (1948), Imperfections in Nearly Perfect Crystals (1950), and Structure and Properties of Solid Surfaces (1952).

The 1958 Conference on Noncrystal-

(*Continued on next page*)

line Solids brought together leading investigators from several fields interested in determining the domain of the term "noncrystalline solids," the structure of such solids, the methods capable of disclosing their structure, and the basis for finding, explaining, and deriving their properties.

The conference papers and the discussion attest to the current extensive progress in characterizing amorphous structures. They create a common ground for dealing with phenomena and fundamentals of distinctly different materials such as glass, evaporated films, and plastics. They also shed light on the character and properties of chemically different glasses (for example, sulfur *versus* silicate glass).

From a theoretical and practical standpoint, this book serves two important purposes—it clarifies and assesses the methods of investigation and the results so far obtained on grossly distorted structures, including those which can no longer be recognized as crystalline; and it makes available to the specialist a body of references from other fields, which would otherwise prove elusive.

High-Speed Testing, Vol. I

Interscience Publishers, Inc., New York, N. Y., (1960); 112 pp.; Illus.; $5.

(A symposium held at Boston, Mass., December 8, 1958. Co-chairmen: A. G. H. Dietz, Frederick R. Eirich.)

Reviewed by Robert Burns, Materials Advisory Board, National Research Council.

THIS LITTLE BOOK has a somewhat complicated parentage. There are the Authors, of course, without whom a book would be rather difficult to breed, by any system of genetics. Then there are the Contributors, and the Co-chairmen of the Symposium, and the Sponsors, and the Publishers, and heaven knows what else. But the book did get published, and a good one at that. Furthermore, additional volumes are planned.

Professor Eirich's splendid introduction explains in straightforward language the difficulties of high-speed testing, and points out that inevitably we run headlong into the phenomenon of brittle fracture, of which we know so little. Seven of the following papers cover testing techniques and resulting data on such materials as plastics, rocket fuels, packaging materials, textile yarns, titanium, and the performance of metals at ballistic rates of loading. An eighth paper treats the theory and practice of stress relaxation. Future volumes will cover other materials.

In reviewing a symposium covering broad and largely unrelated areas one must expect a certain lack of continuity. However, a careful reading, and the volume deserves no other, discloses several unbroken threads running through the fabric. Perhaps outstanding is the general adoption, approaching the routine, of intricate electronic

(*Continued on page 75*)

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(Continued on page 68)

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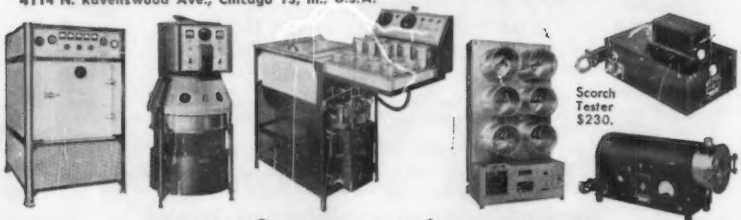


Weather-Ometer® $2755 up.

Fade-Ometer® $1350 up. Complete with supplies.

Launder-Ometer® $875 complete with accessories and supplies.

Random Tumble Pilling Tester $485 to $890.

Scorch Tester $230.

Accelerator® $485.

FOR FURTHER INFORMATION CIRCLE 775 ON READER SERVICE CARD

FIRST in strain measurement

SR-4 | BALDWIN LIMA-HAMILTON BLH

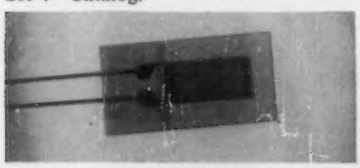
STRAIN MEASUREMENT

DATA SHEET No. 2

HOW TO MATCH THE STRAIN GAGE TO THE JOB

If your business is mechanical design, development or testing, chances are good that you have used, or will some day use, SR-4® Bonded-Filament Strain Gages. Unique in their simplicity, versatility and accuracy, they are the natural answer to a great many problems involving the behavior of materials, components and structures under load.

When the need arises, however, many engineers without specific background in strain-gage techniques find themselves on unfamiliar ground in attempting to select the best gage for the job from over 250 available types. Although it is important to the validity of the results that the gage used be properly suited to the application, selection is normally not a difficult matter and depends principally on known test conditions and on the nature of the data required. When the following criteria have been established, a suitable gage type for a specific application may be readily selected from the SR-4® Catalog.



Bonded foil gage

1. Temperature—The temperature at which the test is to be conducted is an important (frequently limiting) factor in determining suitable grid and base materials. At room and moderately high temperatures, both wire and foil gages are used. At temperatures above 350°F (and at very low temperatures), foil gages must be used. Some types are available with a backing material which may be stripped off during application, the grid alone being bonded to the test area. Such gages may be used up to 1400°F (for dynamic-type tests).

SELECTION OF GAGE MATERIALS BASED ON TEMPERATURE

Maximum Temperature (°F)	Base Material		Filament Material
180	Paper, Bakelite, Epoxy		Any
250	Bakelite, Epoxy		Any
350	Bakelite		Any
600	None	Strippable backing	Constantan or Nichrome foil
1000*	None		Nichrome foil
1400* (dynamic only)	None		Nichrome foil

*Limit imposed by available bonding adhesives

2. Test duration—For short-term tests (a few days) at temperatures below 150°F, paper-base gages are satisfactory and are usually more economical than other types. Extra-thin paper gages speed the curing of the bonding cement for fast application. For longer test periods (months or years), phenolic (Bakelite) or epoxy-base gages are usually used.

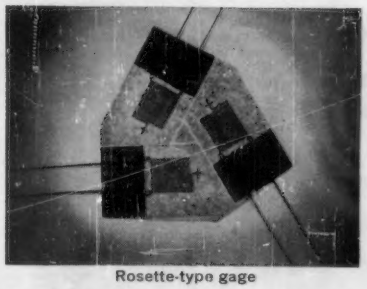
Dual-lead-type gages, with intermediate lead joints, provide good fatigue life. For better fatigue resistance and minimum hysteresis foil gages are advisable. They exhibit combined hysteresis and zero shift of less than 0.10% in strain reversals of up to ±1.5%, have generally higher fatigue resistance than equivalent wire gages.

3. Strain type and magnitude—For static strains, gages having grids of Constantan are usually used up to 600°F. For dynamic strains—particularly those of small magnitude—isoelastic gages are often recommended because of their relatively high strain sensitivity and improved fatigue resistance. Their high sensitivity to temperature change, however, limits usage to the measurement of vibratory strains unless appropriate precautions can be taken to cancel out or allow for this effect. When static strains of high magnitude (±2% to ±10%) are involved, a "post yield" gage is used.

4. Test-area geometry—Gage size depends primarily on the test space available. In general, the largest gage possible should be used. The probable strain gradient of the test area should also be considered, since the strain gage essentially averages the surface strain beneath its grid. When the test space is curved, foil gages are recommended, since they are flexible and will readily assume almost any continuous contour. When small wire gages are used, the new fine-pitch, flat-grid types are generally superior to "wrap-arounds".

5. Strain direction—Single-grid gages are used when the direction of the principal strain to be measured is known. If the strain field is biaxial and the directions are known, a 90°, 2-element rosette gage may be employed. When the strain field is unknown, a 3- or 4-element rosette may be used to determine the direction and magnitude of principal strains.

6. Output requirements—The required gage resistance and sensitivity are frequently dictated to some extent



Rosette-type gage

by the sensitivity of the measuring system to be used. Maximum gage output can be achieved by using a high-resistance gage with maximum bridge voltage.

7. Temperature compensation requirements—Strain gages are sensitive to changes in temperature as well as strain. This temperature effect on the measuring gage can often be canceled out by use of an unstressed "dummy" gage sensing identical temperatures and connected in the strain-gage circuit. In cases where a dummy gage cannot be used, some form of *self*-temperature-compensation is required. There are three general types of temperature-compensating strain gages available.

a. Self-temperature-compensating wire gages—individually compensated for specific materials and specific temperature ranges.

b. "Selected-melt" foil gages—with grids produced from a "melt" of strain-sensing material specifically selected for minimum temperature response over a specific temperature range.

c. Self-temperature-compensating foil gage—a recently developed grid design with an appropriate external circuit, which may be adjusted to provide minimum temperature response on any desired material over any temperature range.

For Engineering Assistance

When tests involve unusual conditions (e.g., high frequencies, strong magnetic or radiation fields, etc.) or necessitate special gage configurations, unusually accurate data, etc., it is advisable to consult your local SR-4® Strain Gage Sales Engineering Representative. He can also supply you with information and specific recommendations on strain-gage instrumentation (static and dynamic), cements, waterproofing compounds, and other accessories.

To obtain a free copy of the latest B-L-H Strain Gage Catalog, write Dept. 4-J

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FOR FURTHER INFORMATION CIRCLE 776 ON READER SERVICE CARD

NEW MEMBERS

(*Continued from page 66*)

Snyder, F. Samuel, project engineer, Piper Aircraft Corp., Box 1928, Vero Beach, Fla.

Southern California District

Belling, Daniel H., manager, Propellants Group, Component Evaluation Laboratory, 1432 Potrero, El Monte, Calif. For mail: 505 Glen Alan, West Covina, Calif.
Chambers, Joseph W., supervisor, materials and process, The Marquardt Corp., 16555 Saticoy St., Van Nuys, Calif.
Darling, Leroy, technical director, Lear, Inc., 11916 Pico Blvd., Los Angeles 64, Calif.
Fingerhut, S. M., manufacturing manager, Zenith Plastics Co., Box 91, Gardena, Calif. For mail: 923 S. Ogden Dr., Los Angeles 36, Calif.
Gray, Robert D., chief chemist, National Seal Div., Federal-Mogul-Bower Bearings, Inc., 11634 Patton Rd., Downey, Calif.
Lewis, George R., quality control, Deutsch Molding, Inc., 21043 Wilmington, Long Beach 10, Calif.
Saunders, Charles J., laboratory technician, Los Angeles Department of Water and Power, Valley Steam Plant, 9430 San Fernando Rd., Sun Valley, Calif. [A]

Southwest District

Lindinger, Joe L., president, Lindinger Inspection Engineers, Box 25023, Houston 5, Tex.
Sprow, Donald L., metallurgist, McDermott Fabricators, Box 188, Morgan City, La.
Whalen, Frank B., administrative and project engineer, Lone Star Boat Co., Box 1050, Grand Prairie, Tex.

Washington D. C. District

Larsen Products Corp., Daniel K. Donovan, research engineer, P. O. Drawer 5938, Bethesda 14, Md.
Standard Lime and Cement Co., Nelson H. Kehl, ceramic engineer, Martinsburg, W. Va.
Bejuki, Walter M., assistant director, Prevention of Deterioration Center, National Research Council, 2101 Constitution Ave., Washington 25, D. C.
Casanova, Arturo Y., III, highway research engineer, Bureau of Public Roads, Washington 25, D. C.
Holmes, R. R., chief chemist, Chemical Laboratory, Western Maryland Railway Co., Hagerstown, Md.
Maisel, William Harrison, chemist, Harry T. Campbell Sons' Corp., Towson 4, Md.
North Carolina State College, Mineral Research Laboratory, Raleigh, N. C.

Western New York–Ontario District

Francisconi, Louis, process engineer, James Cunningham Son and Co., Inc., Box 516, Rochester 2, N. Y. [A]

Outside Established Districts

Alsmeyer, William C., vice-president, Leo A. Daly Co., 8600 Indian Hills Dr., Omaha 14, Nebr.
Johnson, Rodney B., metallurgical engineer, Rockwell Manufacturing Co., Kearney Div., Box 424, Kearney, Nebr. [A]
Judson, C. J., chief engineer, Hoffman-University-Industrial, Box 691, Pasco, Wash.

Other Than U S Possessions

Royal Blast Furnace and Steel Plants, Ltd., Research and Control Laboratories, P. A. Veldheer, librarian, Ijmuiden, Holland.
Castellot Fernandez, Alberto, consultant in electroplating, Vilamari 126-1°, Barcelona 15, Spain. [A]
Dawance, Victor, chief engineer, Societe des Usines a Tubes de la Meuse, Flemalle-Haute, Belgium.
Felix, Werner, Sulzer Brothers, Ltd., Dept. 15, Winterthur, Switzerland.
Jimenez Ruiz, Tobias, technical director, Concretos Premezclados, S. A., Union 101-A, Mexico 18, D. F., Mexico. For mail: Jose MaVigil 107, Mexico 18, D. F., Mexico.
Patterson, Lloyd H., manager, dispatching, Trans Mountain Oil Pipe Line Co., 400 E. Broadway, Vancouver 9, B. C., Canada.
Rikles, Bernardo, director, Tecnastar S. A. de Ingenieria, San Martin 663, Piso 6, Buenos Aires, Argentina.
Sanderson, Emmerson R., president, E. R. Sanderson and Co., Inc., Shurdut Bldg., Intramuros, Box 1447, Manila, Philippines.
Soderberg, Lennart, manager of quality control, A. B. Svenska Metallverken, Finspong, Sweden.
Suomen Standardisoimisliitto, A. Willberg, director, Ratakatu 9, Helsinki, Finland.
Tallant, John A., managing director, Phillips Carbon Black Co. (Pty.), Ltd., Box 862, Port Elizabeth, South Africa.
Vinayaka, M. R., research officer, Concrete Laboratory, Koyna Hydro Electric Project, Government of Maharashtra, Koyna, Maharashtra, India.

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The qualities of mind and spirit of scientists and technologists engaged upon a constant search for what is true have proved to be one of man's very greatest intellectual and moral achievements of the past four or five hundred years.

. . . David E. Lilienthal, "Science and Man"
Chemical and Engineering News, Sept. 29, 1958

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MI-2 UNIVERSAL TESTING MACHINE WITH GRAPHIC RECORDING
TENSION • SHEAR • BENDING • COMPRESSION • HARDNESS AT AMBIENT AND ELEVATED TEMPERATURES.
MAXIMUM LOAD 5000 LBS.
(3 INTERCHANGEABLE DYNAMETER SPRINGS AVAILABLE.)

For medium size specimens, the MI-2 is exceptionally accurate and simple to operate. It graphically records load-deformation diagrams and results in added economy through the small-sized specimens required.

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• TENSION • SHEAR • BENDING
MAXIMUM LOAD 700 LBS.
(4 INTERCHANGEABLE DYNAMOMETER SPRINGS AVAILABLE.)

A specially designed machine for the investigation of very small specimens, the MI-3 measures deflection through a dynamometer spring and records it photographically employing a flawless optical tripod system.
Electronically driven and controlled, the MI-3 allows derived curves giving data in the micro-crystalline orders of magnitude.

MI-4 MICROMACHINES WITH PHOTOGRAPHIC RECORDING
TENSION IN METALLIC WIRES AND STRIPS, TEXTILE FIBERS AND THREADS, FABRICS AND PAPERS, AT LOW, AMBIENT AND HIGH TEMPERATURES.
MAXIMUM LOADS: MI-44/I 500 GR., MI-44/II 150 LBS., MI-44/III 200 LBS.
(18 INTERCHANGEABLE DYNAMOMETER SPRINGS AVAILABLE)

In two sizes, the MI-44/1 and MI-44/2 photographically record stress-strain diagrams through a flawless optical tripod system. With two tripods, one direct mounted and the other differentially mounted, a wide test range is assured.
Silicone Steel dynamometer springs and electronically controlled motors make the MI-4 machines fast and accurate.

MI-5 MICROMACHINE WITH PHOTOGRAPHIC RECORDING
ALTERNATING TORSION-MAX COUPLE ± 0.05 kgm

To determine the fatigue limit of a specimen, for determination of internal friction from the energy dissipated per alternation, and to follow the progress of fatigue as a function of the number of alternations the MI-5 is an unexcelled performer.

MI-8 THERMOBALANCE

With mechanical or photographic recording, the applications are manifold. Designed to be insensitive to vibration and change in ambient temperature, it is especially useful for the most critical analysis of:

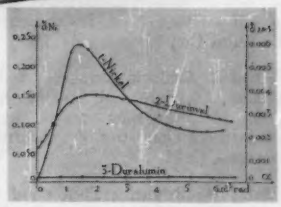
- Dry oxidation of metals and alloys
- Solid system changes accompanied by addition or loss of gas or vapor
- Dissociation of true chemical compounds formed when a gas is absorbed by a solid
- Thermal data on the calcination of precipitates
- Drying products in powder form

MI-9 MICROPENDULUM "COULOMB"

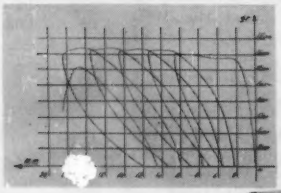
Specially designed for a specific field of testing, the MI-9, through attenuated oscillations, determines:

- The variations of internal friction in metals
- Magneto-elastic anomalities of metals and ferromagnetic alloys
- Changes of internal friction due to cold working
- The mechanical hysteresis and fatigue of metals.

MI-9

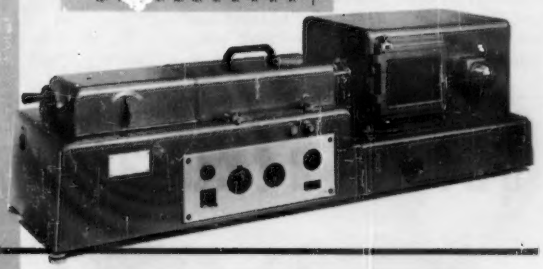


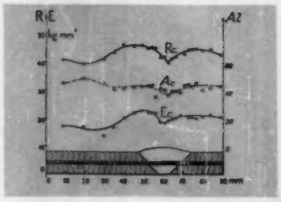
Curves plotted by evaluating the damping diagrams. On the Nickel and Durinval curves the magneto-elastic anomalities inherent to ferromagnetic materials is clearly defined.
The very slight decrement of Duralumin is so-to-say independent of the amplitude.



MI-44

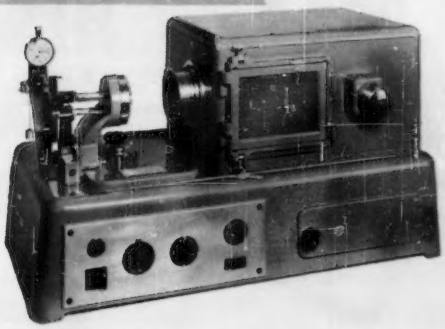
Load-deformation curves of flat, colorless extruded polyethelyne, employing a 3 kg. maximum capacity dynamometer.





MI-34

Detailed investigation of a weld made by carrying out Micro Shearing tests. A Chromium-Molybdenum steel welded with an electrode of the same material.



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NEWS OF MEMBERS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

John W. Allen, formerly with The Atomic Energy Commission's Oak Ridge National Laboratory, Oak Ridge, Tenn., has been appointed manager, engineering, nondestructive testing, Instruments Div., The Budd Co., Phoenixville, Pa.

Floyd B. Ashlock, formerly mechanical engineer, McClure and Associates, Kirkwood, Mo., is now design engineer, Standard Oil Company of California, San Francisco, Calif.

Harry A. Bright, retired chief of the analytical chemistry section, Division of Chemistry, National Bureau of Standards, Washington, D. C., received the 1960 Anachem Award of the Association of Analytical Chemists. The award is presented for "Outstanding Achievement in Analytical Chemistry."

G. H. Clamer, Ajax Metal Div., H. Kramer and Co., Philadelphia, Pa., was honored on his 85th birthday by the Brass and Bronze Ingot Inst. Dr. Clamer has been a member of ASTM since 1902, is an Honorary Member and Past-President.

Charles H. Commons, Jr., is senior research fellow, Pfaudler-Permutit, Inc., Rochester, N. Y. Previously he was head, Ceramic Dept., Foote Mineral Co., Berwyn, Pa.

Robert M. Crichton has resigned as city engineer, Hood River, Ore. He is now a consulting engineer in Hood River.

Alfred G. Fleisch has joined Flagg Tanning Co., Milwaukee, Wis., as chief chemist. Formerly he served in the same capacity for Pfister Vogel Tanning Co., Milwaukee.

Donald A. Forbes, previously director of research, Hamilton Porcelains, Ltd., Brantford, Ont., Canada, is now chief development engineer, Corning Glass Works, Corning, N. Y.

Fredrick P. Glazier has joined the Sun Oil Co., Philadelphia, Pa. Formerly he was vice-president, Laboratory Equipment Co., Mooresville, Ind.

D. W. Hange, prior to becoming a highway engineer for the U. S. Forest Service, Nevada City, Calif., was hydraulic engineer, U. S. Department of the Army, Jacksonville Florida District, Neptune Beach, Fla.

T. M. Hill, Aluminum Company of America, Pittsburgh, Pa., retired in August. Dr. Hill served as secretary of Committee F-2 on Flexible Barrier Materials since its organization in 1958.

C. A. Johnson, chemical engineer, Socony Mobil Oil Co., Inc., New York, N. Y., retired October 1, 1960. Mr. Johnson is continuing his membership in the Society and on Committee D-27 on Electrical Insulating Liquids and Gases, which committee he serves as recording secretary.

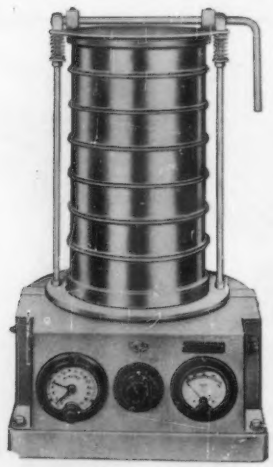
Kenneth A. Kaufman, formerly supervisor, market research and development, Amoco Chemical Co., Chicago, Ill., is now assistant director, research and development, Rexall Chemical Co., Paramus, N. J.

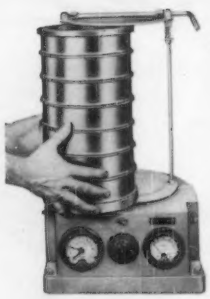
George H. Kimber has been elected chairman of the board, Calcium Chloride Inst., Washington, D. C. He had been president.

I. E. Knapp, technical director, Southern Naval Stor · Div., Leach Brothers, Inc., Columbia, Miss., retired after 30 years, but will continue to serve in a consulting capacity. An active member of the Society since 1945, Mr. Knapp has

(*Continued on page 72*)

quick, accurate sieve analysis with





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- **FULL 10 INCH CHART**
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This new Sargent Polarograph gives you a large 250 mm (10 inches) chart and the highest accuracy and current sensitivity at the lowest price of any pen writing polarographic instrument on the market.

It offers you optimum specifications based on over twenty years of leadership in design, manufacture and service in this specialized field of analysis.

The polarographic method is capable of reproducibility to 1/10% and analytical accuracy to ½%. To make use of this facility, the instrument must be accurate to 1/10% and chart space must be provided for recording large steps to achieve measuring precision. We strongly advise against the purchase of any polarographic instrument using miniature (5 inch) charts and low gain balancing systems in the 1% order of precision.

This Model XV is adaptable to 10^{-6} M determinations with the S-29315 Micro Range Extender.

®Registered Trade Mark (Pat. No. 2,931,964)

Current Ranges:	19, from .003 to 1.0 μA/mm.
Current Sensitivity:	standard specifications, 10^{-4}μA/mm.
Polarizing Ranges, volts:	0 to −1; −1 to −2; −2 to −3; −3 to −4; +.5 to −5; 0 to −2; −2 to −4; +1 to −1; 0 to −3; +1.5 to −1.5.
Balancing Speed:	standard, 10 seconds; 1 second or 4 seconds optional.
Bridge Drive:	synchronous, continuous repeating, reversible; rotation time, 10 minutes.
Chart Scale:	current axis, 250 mm; voltage axis, 10 inches equals one bridge revolution.
Current Accuracy:	1/10%
Voltage Accuracy:	¼%
Chart Drive:	synchronous, 1 inch per minute standard; other speeds optional.
Writing Plate:	10½ x 12½ inches; angle of slope, 30°.
Standardization:	manual against internal cadmium sulfate standard cell for both current and voltage.
Damping:	RC, four stage.
Pen:	ball point; Leroy type optional.
Suppression:	zero displacement control, mercury cell powered, 6 times chart width, upscale or downscale.
Potentiometric Range:	2.5 millivolts, usable as general potentiometric recorder.
Finish:	case, enameled steel; panels, anodized aluminum; writing plate, polished stainless steel; knobs and dials, chromium plated and buffed.
Dimensions:	23 x 17 x 10.
Net Weight:	65 pounds.

Catalog number **S-29310** with accessories and supplies. . . . **$1585.00**

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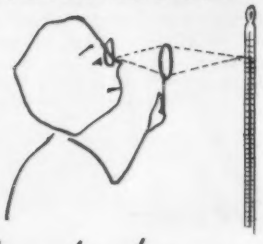
Once Upon a Time
there was a
Thermometer Watcher



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write reports
and
think !!!

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CIRCLE 781 ON READER SERVICE CARD

NEWS OF MEMBERS

(*Continued from page 70*)

served on Committees D-1 on Paint, Varnish, Lacquer, and Related Products and D-17 on Naval Stores.

H. W. Ladd, superintendent of materials, Producing Dept., Pan American Petroleum Corp., Tulsa, Okla., is now retired. Mr. Ladd joined the Society in 1945 and participated in the activities of Committee A-1 on Steel.

John E. Lyons is now civil engineer, Esso Research and Engineering Co., Madison, N. J. Formerly he was assistant professor, Arizona State University, Tempe, Ariz.

Richard R. Moore, chief metallurgist, Naval Air Engineering Facility, Naval Air Material Center, Philadelphia Naval Base, Philadelphia, Pa., received a Certificate of Merit from the Franklin Inst., Philadelphia, Pa., at formal ceremonies October 19. The award is presented to persons "adjudged worthy thereof for meritorious inventions, discoveries or improvements in physical processes or devices."

James F. Morgan, Jr., is now associated with Uhl, Hall, & Rich, Niagara Falls, N. Y. He had been quality control engineer, Buffalo Crushed Stone Corp., Bowmansville, N. Y.

Donald T. O'Connor has been appointed director of research and development, Magnaflux Corp., Chicago, Ill. Previously he was chief engineer, X-Ray Tube Div., Machlett Laboratories, Inc., Springdale, Conn.

Robert B. Oliver, formerly manager, Lawrence Radiation Laboratory, Danville, Calif., is now supervisor, nondestructive testing, Aerojet-General Corp., Sacramento, Calif.

Walter L. Pinner, The McGean Chemical Co., Cleveland, Ohio, received the Charles Henry Proctor Memorial Leadership Award, presented for the first time by the American Electroplaters' Society at the Society's convention in July. Mr. Pinner was cited for the strength and significance of his leadership in heading the Society's International Conference in 1959 that enriched world knowledge in electroplating, metal finishing, organic coating, and allied arts through 43 papers delivered by experts of nine countries.

John T. Reinhard is now president, Hydro Mat Linings, Inc., Ann Arbor, Mich. Previously he was quality control engineer, Ann Arbor Construction Co., Ann Arbor.

Emanuel Rosenblat, formerly safety engineer, Mt. Vernon, N. Y., is now president, Arlin Chemicals, Inc., Carlstadt, N. J.

A. O. Schaefer was made corporation metallurgist for Struthers Wells Corp., Titusville, Pa. He was formerly associated with Pencoyd Steel and Forge Corp., Philadelphia, Pa.

W. E. Scoville, formerly supervisor, Process and Product Development Laboratories, Standard Oil Company (Ohio), Cleveland, Ohio, has been appointed supervisor, Planning and Information Section, Commercial Development Unit. This new unit, established on July 1, is concerned with investigating and developing new business opportunities appropriate to the activities of the company. Mr. Scoville has been a very active member of ASTM Committee D-2 on Petroleum Products and Lubricants, a member of its Advisory Committee, and has served the Society very ably in other capacities, including long-range planning studies.

Hubert R. Snoke, assistant chief, Building Technology Div., and chief, Floor, Roof, and Wall Coverings Section, National Bureau of Standards, Washington, D. C., retired July 31 after more than 40 years with the Bureau. Dr. Snoke is a 30-year member of ASTM. He is continuing his membership in the Society, and on the committees he has served through the years.

James P. Thompson is now associated with the American Institute of Timber Constructions, Washington, D. C. He had been a structural engineer for the National Bureau of Standards, Washington.

S. A. Wenk, previously manager, Radiographic Div., Applied Radiation Corp., Walnut Creek, Calif., is now manager, accelerator applications, Varian Associates, Palo Alto, Calif.

William A. Wildhack had been appointed special assistant to the director, National Bureau of Standards, Washington, D. C. One of his major assignments will be to explore and keep abreast of the needs of industry and other government agencies for precision standards, calibration services, and improved measurement techniques, particularly those which may require extension of the Bureau's capabilities. He will continue to serve as an advisor on the Bureau's activities in instrumentation research and development.

Elias Zolkov is chief soils engineer, Israel Standards Inst., Shekh Munis, Tel Aviv, Israel. He had been civil engineer, Technion—Israel Institute of Technology, Haifa, Israel.

DEATHS

D. W. Bender, Stark Div., Republic Steel Corp., Canton, Ohio (July 2, 1960). Mr. Bender represented his company on Committee A-5 on Corrosion of Iron and Steel.

O. E. Fawcett, West Penn Power Co., Springdale, Pa. (August 7, 1960). For a number of years, Mr. Fawcett represented his company on Committee D-9 on Electrical Insulating Materials.

James M. Scott, general plant manager and treasurer, Scott Testers, Inc., Provi-

(*Continued on page 75*)

from **HIGH VOLTAGE ENGINEERING . . .** the most complete line of supervoltage and high energy radiographic equipment for non-destructive testing and . . . .

EVALUATION OF REACTOR MATERIALS AND COMPONENTS . . . .

. . . 1 to 15 Mev X-Rays for high-speed, precise radiographic examination of special nuclear materials including high-density alloys, fuel elements, heat exchangers, pressure vessels, valves, control mechanisms *to meet rigid government inspection standards.*

SUPERVOLTAGE

- 1 and 2 Mev Van de Graaff X-Ray Generators
- Penetration: ½" to 11" equivalent steel thickness
- Mount Options: Fixed, truck, or flexible crane

Performance Characteristics

Model	Energy (Mev)	X-Ray Intensity 1 meter from source (r/min)	Focal Spot (mm)
JR	1	8	1
AR	2	75	1

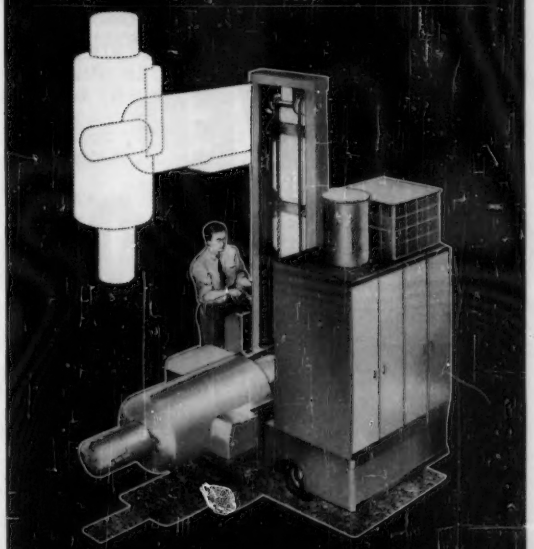
Model JR, 1 Mev Van de Graaff x-ray generator used for inspection of fuel elements. *Courtesy Babcock & Wilcox Co.*

HIGH ENERGY

- 8-15 Mev Linac X-Ray Generators
- Penetration: 2" to 25" equivalent steel thickness
- Mount Options: Fixed, truck, or flexible crane

Performance Characteristics

Model	Energy (Mev)	X-Ray Intensity 1 meter from source (r/min)	Focal Spot (mm)
LR-8	8	1500-6000	1-5
LR-12	12	2300-18000	1-8
LR-15*	15	3000	1



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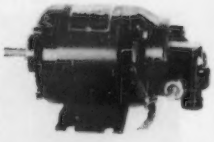

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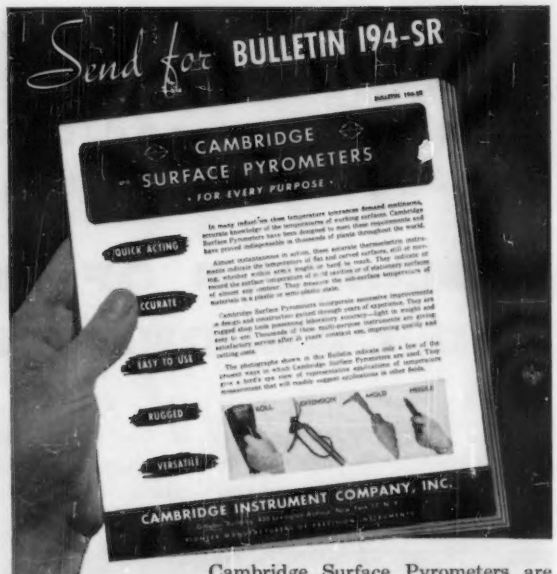

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monates, Sodium antimonides, Sodium antimonit
arsenates, arse Sodium arseniphc
Sodium a osulfate,
cuprate, ium barbit
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sulfate, Sodium b triphosphate, Sodium b
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DEATHS

(*Continued from page 72*)

dence, R. I., and president of its affiliate, Scott Testers Southern, Spartanburg, S. C. (June 20, 1960). Mr. Scott, through his firm, had been active in ASTM technical committee work for many years.

Rudolph M. Snyder, director, Industrial Testing Laboratory, Kansas City, Mo. (January 2, 1959). Mr. Snyder joined ASTM in 1940.

David B. Steinman, consulting engineer, 117 Liberty St., New York, N. Y. (August, 1960). Mr. Steinman had been a member of the Society since 1927.

Hartwell Whitney, chief engineer, Electric Steel Foundry Co., Portland, Ore. (May 22, 1960). Mr. Whitney represented his company on Committees E-3 on Emission Spectroscopy, E-3 on Chemical Analysis of Metals, and E-7 on Nondestructive Testing.

BOOKSHELF

(*Continued from page 65*)

equipment for determining the stress-strain-time relationship at high speeds. Though much remains in the development of load bars, strain gages, and the like, responsive in the millisecond and microsecond range for input to the oscilloscope, at least we have made the big jump from the less-than-adequate "static" testing of a relatively few years ago.

One of the difficulties in studying a book of heterogenous content is lack of understanding of terms. To the specialist in a given area there is no problem, but the reader of this book is looking for education in high-speed testing. Therefore, it is highly desirable that units of stress, time, velocity, etc., be spelled out on first appearance; in a few years, perhaps, the high-speed boys can adopt some across-the-board standardization of units. While appreciating the excellent paper on theory and practice, this reviewer was forced to take a short course in quantum mechanics in order to understand one of the symbols. This was tough, but if it's the price of education, so be it.

Encyclopedia of Electrical Insulating Materials

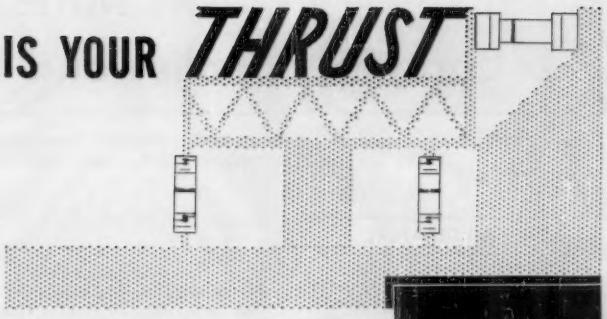
Compiled by the Swiss Electrotechnical Committee, Zurich 8, Switzerland, under auspices of the International Electrotechnical Commission; 48 pp.; 8 1/4 by 11 3/4 in.; about $5; available in English, French, and German.

Reviewed by G. Dochnahl, ASTM Staff.

THE PURPOSEFUL selection of insulating materials for electrical applications is becoming steadily more difficult because of the increasing number of raw materials available for this purpose, the rapid evolution of new electrical devices, and the variety of requirements to be met. Since the

(*Continued on page 84*)

IS YOUR THRUST



- Too low?
- Too high?
- Questionable?

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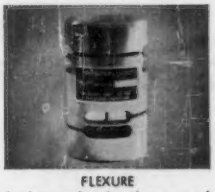
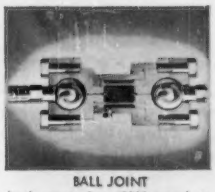
LOAD CELL
available in accuracies to .05% in single and multi-bridges



FLEXURE
load ranges from less than a pound to millions



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load ranges from 2000 pounds to millions

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NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note. This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

CATALOGS & LITERATURE

Testing Insulating Materials—A new *Manual G-65* on methods and equipment for testing insulating materials has just been compiled. Some of the wide range of subjects covered in this new manual are: high-voltage breakdown testing of insulating materials in accordance with ASTM specifications; automatic rate-of-rise control for high-voltage breakdown testing of insulating materials; determining resistance to arcing of insulating materials.
Associated Research, Inc. 6314

Strain Gages—A new 28-page SR-4 strain gage specification and price list, *No. 4310-60*, has been released. The new catalog contains price information and technical specifications for over 350 types of strain gages plus a complete line of strain gage instruments and accessories currently available.
Baldwin-Lima-Hamilton Corp. 6315

Metal Grinding—*Metal Digest*, No. 3, Vol. 6, features pertinent information on the all-new 1255 AB surfmet machine for coarse grinding of metallurgical samples. Units are available for wet or dry grinding.
Buehler, Ltd. 6316

Gravitometer—Details about the applications, installation, operation, and maintenance of the new Sinclair-Cenco 35090 continuous recording gravitometer have been published. The gravitometer itself makes continuous "on-line" measurements of the specific gravity of flowing liquids from within a 40-deg API range. These measurements can be used for controlling the continuous blending of liquids, routing pipeline runs to remote bulk storage facilities, or in almost any situation where the handling of bulk fluids may be automated.
Central Scientific Co. 6317

Electrodes—A new 20-page illustrated *Booklet NH-504* giving complete information on arc welding electrodes, including specifications, chemical requirements, and methods of estimating electrode consumption is available. AWS and ASTM specifications are explained and listed for mild, low-allow, and stainless-steel electrodes; chemical requirements for all weld metals are given; and welding characteristics of mild steel electrodes are listed.
Chemetron Corp. 6318

Vacuum Coating—New 28-page pamphlet, *Bulletin 2-2*, describes vacuum coating and equipment in the high-vacuum field.
Consolidated Vacuum Corp. 6319

Magnetic Pickup—A new descriptive booklet on magnetic pickups is announced. *Bulletin CMP 50* is designed to assist potential users of these self-generating input devices in selecting the pickup best adapted to their specific needs.
Electro Products Laboratories 6320

Precision Balances—General-purpose high-speed precision balances, designed for small-capacity industrial weighing operations of all types, are described and illustrated in a new *Bulletin No. 3414*.
The Exact Weight Scale Co. 6321

Potentiometers—A six-page catalog describes a full line of high-precision, single-turn, wirewound potentiometers suitable for missile and space age applica-

(*Continued on page 78*)

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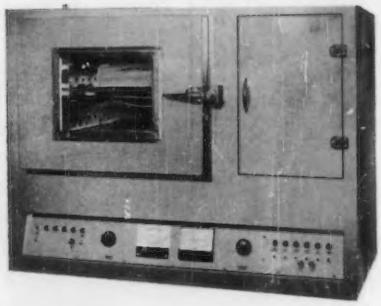
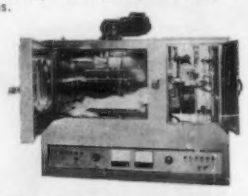


Orec 0300 Series employ an *electronic-chemical loop feed back servo system to achieve and precisely maintain chamber ozone concentrations.



Orec 0300 with Dynamic Stretching Apparatus.
* patent pending

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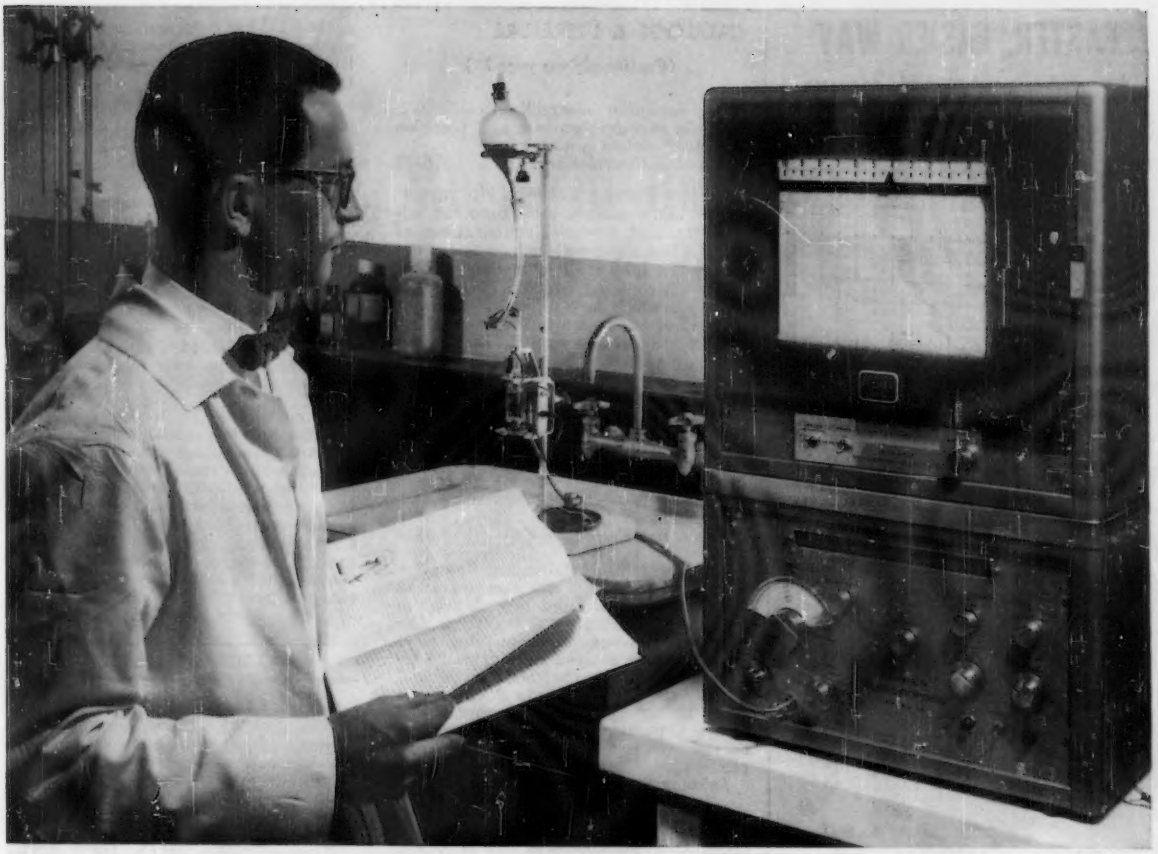

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Modern electronic design has increased the usefulness of the all-new Model 65 Elecdropode. Its extended potential range makes possible the accurate qualitative and quantitative analysis of a greater variety of inorganic, organic and biological materials. There are polarographic methods for trace metals in alloys or body fluids . . . for alkaloids and antibiotics . . . for oxygen, halides and many other positive and negative ions.

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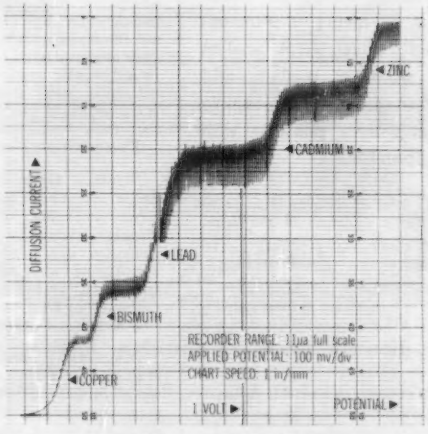
The stable power supply requires no vacuum tubes or batteries, except a mercury reference cell. The Elecdropode runs directly on any 115-volt, 50- or 60-cycle a-c line.

For full details, please write: Fisher Scientific Company, 107 Fisher Building, Pittsburgh 19, Pa. B-102



In this polarogram, made automatically with the Model 66 Recorder, the Elecdropode has identified and measured the concentrations of five different metals in the same sample.

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Developed specially for the ASTM D-2 Fluorescent Indicator Adsorption Method, the Jarrell-Ash Phillips "Chromanalyzer"® enables the petroleum analyst to determine aromatic, olefinic, and saturated hydrocarbons more rapidly and conveniently than possible with existing F-I-A apparatus.

- Shorter (3-foot) columns require less transit time; are less fragile, easier to fill and clean.
- Operates under normal room lighting — no darkroom required.
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- Boundary points mechanically recorded in ink on strip chart.
- Compact, self-contained instrument occupies only 16" x 25" of bench space.
- Accommodates up to eight samples.

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CATALOGS & LITERATURE

(*Continued from page 76*)

tions, computer assemblies, calibration controls, servomechanisms, and precision industrial control systems.
Fairchild Controls Corp. 6322

Column Packing Kits—Six kits consisting of liquid phases, solid supports, adsorbents, and prepared combinations of liquid phases and solid supports for gas chromatography are now made available. These kits contain from 20 to 50 g of each material, which is sufficient to pack at least 12 ft of column and more. These kits permit low-cost experimentation for determining suitable column packing materials for optimum gas-chromatographic separations.
F & M Scientific Corp. 6323

Power Source—A two-page technical *Bulletin No. 502* describing the new Model LDS-1500 50-w, low-distortion, variable-frequency power source has just been published.
Krohn-Hite Corp. 6324

Spectrographic Metallurgical Control—A technical bulletin on spectrographic metallurgical control and its application to high-alloy steel castings is available. The bulletin discusses the advantages of spectrographic analysis as compared with conventional "wet" chemical analysis and outlines the benefits to the steel castings user through increased accuracy of analyses, production speed, and uniform control and dependability of the end product.
Lebanon Steel Foundry 6325

Centrifuge—A 16-page fully illustrated catalog is designed to offer finger-tip reference to the complete line of centrifuges. It also lists in detail the rotors and attachments produced for each model.
Lourdes Instrument Corp. 6326

Electronics in Testing Machines—"Tinius Talks About the Role of Electronics in Testing Machines" is the title of an informative eight-page brochure, which traces the development of the electronic null balance principle used on the Selectorange indication system, as well as in stress-strain recorders and strain instrumentation. Recent developments in automatic readout systems for printing ultimate and intermediate test data, such as yield strength, and low-capacity load cells are also discussed.
Tinius Olsen Testing Machine Co. 6327

Strain Gage—New *Bulletin 360* describes the Model HW-1 portable strain indicator. It describes a unique circuit design by which the new PIC indicator eliminates the time-consuming operations normally involved in phase balancing to compensate for distributed capacity in lead wires.
Polyphase Instrument Co. 6328

Magnetic Memories — Technical *Bulletin 59-J* describes series 3100 magnetic memories, versatile coincident-current, random-access storage units for data-processing applications, with capacities ranging from 128 to 4096 words and from 4 to 64 bits per words. The four-page illustrated bulletin contains a full description, block diagram, and timing chart.
Rese Engineering, Inc. 6329

Water Bath—A heavy-duty, constant-temperature, water-bath shaker which controls temperatures within ±0.5 C up to 90 C has been announced. Choices of shaking patterns include three stroke lengths—, ½, 1, 1½in.—and any speed from 40 to 200 cpm.
Research Specialties Co. 6330

Gaging Instrumentation—Designated *Catalog No. G-100*, a four-page, three-color, illustrated brochure describes in detail the systems and components available for the continuous indicating and monitoring of minute changes in dimensions for control usages.
Schaevitz Engineering 6331

Edgegraphing—Edgegraphing, a new technique for hand analysis of complex engineering data in 10, 20, or more variables, is included in 16 pages of technical literature now available.
Statistical Engineering Inst. 6332

Tear Tester—The torsion tear tester was developed to measure shear strength or tearing resistance of strongly directional materials which are difficult to measure by other test methods. Reinforced shipping tape, corrugated boxboard, textiles, highly calendered rubber stocks, etc., usually tear at right angles to the direction of greatest strength. *Bulletin 265* describes the instrument and the method of operation and gives typical applications.
Thwing-Albert Instrument Co. 6333

LABORATORY ITEMS

Analyzer—A new instrument capable of exciting, measuring, and recording phosphorescence of innumerable compounds is the Aminco-Keirs spectrophosphorimeter. It permits excitation of compounds and measurement of resulting phosphorescence throughout the ultraviolet and visible regions.
American Instrument Co., Inc. 3511

Launder-Ometer—A new model Launder-Ometer which may be operated at temperatures up to 300 F is announced. For high-temperature dyeing, up to 20 new high-pressure stainless steel containers, 3 by 6 in., may be used simultaneously. The containers are provided with fittings which permit injection of additives during test and release of any built-up pressure before opening.
Atlas Electric Devices Co. 3512

Mercury Meter—Three new mercury vapor meters—Models 21, 23, and 24—which provide instantaneous, direct readings of the toxicity levels of mercury vapor in enclosed areas are now available.
Beckman Scientific and Process Instruments Div. 3513

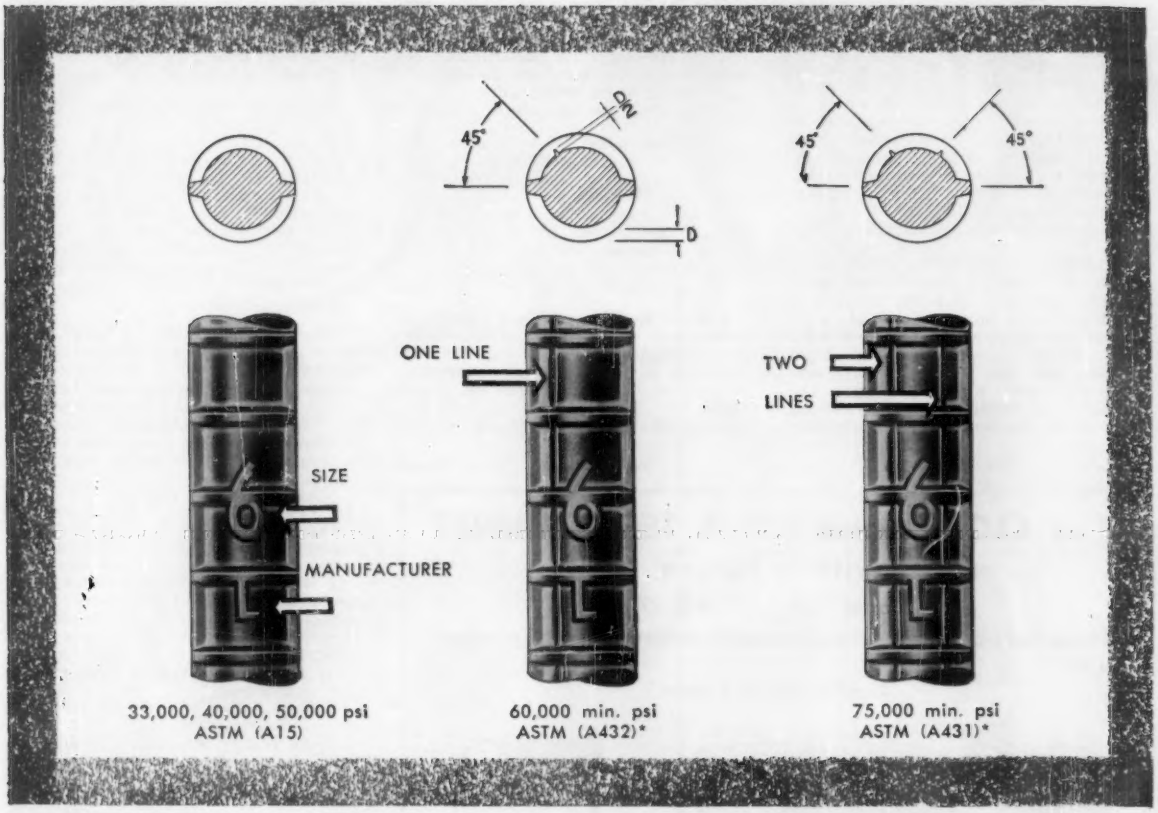
Incremental Recorder—High-speed, precision plotting of computer-processed data is made possible with a new X-Y recorder. The recorder, Model 560, converts digital information regarding the relative variation of two functions into corresponding incremental motions of the plotting paper and the plotting pen. This graphical representation of the relationship between the two functions is accurate to within 0.01 in., the size of the basic plotting increment.
California Computer Products, Inc. 3514

Optical Transducer—Addition of an optical transducer to the line of fractional-horsepower motor testing equipment is announced. The purpose of this transducer is to obtain stable electrical pulses proportional to rotational velocity. It

(*Continued on page 80*)

NOW...

Every LACLEDE Multi-rib Reinforcing Bar is Marked to Show SIZE and STRENGTH...



Standard high strength steels* permitting greater economy and efficiency in reinforced concrete design under the provisions of the new A.C.I. codes must be **identified.** Recognizing this need, each Laclede Multi-rib reinforcing bar can now be completely identified as to size, strength and origin through a new rolled-in marking system. This assures the designer, contractor, and code writer that the proper grade of reinforcement is used on the job.

Demand these new time-saving Laclede bars for your next construction job.

LACLEDE

LACLEDE STEEL COMPANY

SAINT LOUIS, MISSOURI ◆ Producers of Steel for Industry and Construction

FOR FURTHER INFORMATION CIRCLE 791 ON READER SERVICE CARD

(*Continued from page 78*)

serves as an input source for decade counters and other pulse-operated tachometers. The primary advantages of this transducer are extreme sensitivity without amplification, nearly flat response over a wide frequency range, a minimum of required maintenance, and exceptionally rugged long life owing to the absence of vacuum tubes.
John Chatillon & Sons 3515

Accelerometer—The development of a new subminiature piezoelectric accelerometer, Model 606, designed for use in special shock and vibration test applications where small size and light weight are the prime considerations, has been announced. The Model 606 is a stainless-steel accelerometer only ¼ in. high, weighing just 1.0 g. It permits many in-flight tests that could not normally be conducted with standard-size or miniature-size pickups. The unit has a sensitivity of 2.5 peak mv per peak *g* and a frequency response of 5 cps to 10 kc., with its resonant frequency at 135 kc.
Columbia Research Laboratories 3516

High-Pressure Test—The requirement for the use of high-pressure test equipment (up to 15,000 psi), which can be taken to any location in a hurry and put into work immediately on arrival, has been met in this new mobile equipment. The high-pressure test unit is a completely self-contained unit which precludes the necessity of assembling and moving cumbersome stationary-type equipment. The unit is fitted into a highly mobile four-wheel-drive truck.
Consolidated American Services, Inc. 3517

Microscope Readings—Now being produced in quantity, a data acquisition and recording system is speeding up tedious microscope readings at a number of research institutions and universities. The system converts the translational motions along three orthogonally related axes of a film-scanning microscope into coded digital data on punched paper tape. Each of the three axes uses one encoder assembly. These provide 1000 counts per input shaft revolution and have a total capacity of 100,000 counts. Accuracy of the encoder assemblies is ±1 count.
Datex Corp. 3518

Moisture Separator—The latest, improved apparatus for determining the amount of moisture and fats in biological materials has been announced.
Delmar Scientific Laboratories 3519

Push-Pull Gage—This versatile new instrument does the work of two separate compression and tension measuring devices. The unique split-dial gives readings of compression loads and tension loads. Also, it can be hooked into a system to measure and control oscillating loads in compression and tension.
W. C. Dillon & Co., Inc. 3520

Silicon Rectifier—A new series of hermetically sealed silicon rectifier diodes, featuring high stability, extreme versatility, miniature design, and rugged construction at low cost, has been announced. Designated as DI-52, 54, 56, 58, and 510, these diodes have peak inverse voltage ratings of 200, 400, 600, 800, and 1000 v, respectively. All five types handle 750 ma at 25 C and 500 ma at 100 C.
Diodes, Inc. 3521

X-Ray Films—Easy-to-handle, individual sheets of Kodak industrial X-ray film individually wrapped in convenient packaging has been introduced. Light-tight ready-packs permit easy handling of individual sheets of film throughout the exposure operation.
Eastman Kodak Co. 3522

Temperature Indicator—A 2-lb battery-powered portable temperature indicator has been developed. The unit has thermistor sensing probes and batteries having an estimated life of several thousand hours. It is available in ten different ranges, spanning −30 to 350 F, and uses interchangeable probes for air, liquid, and surface temperature sensing.
Fenwal, Inc. 3523

Laboratory Glassware—A full line of laboratory glassware items, clearly identified with the AEC symbol reading: "Caution—Radioactive Material," is now available. This positive, permanent marking greatly reduces the radiation hazards that exist with poor or makeshift identification methods and is particularly important in the washing of laboratory glassware, for it is here that most human classification errors are apt to occur.
Fischer & Porter Co. 3524

Pressure Transducer—A new automatic pressure transducer calibration system has been announced. The heart of the system is an automatic weight handling device. A binary coded decimal system is used to effect the automatic placing of weights on a balance pan so that a range of 0 to 3500 psi is covered by 1-psi increments.
Gilmore Industries, Inc. 3525

Exposuremeter—A new ultrasensitive exposure meter for photomicrography known as "Remiphot" is now available. The Remiphot can be used for exposure measurement with any camera-microscope combination. This universal application becomes possible through the use of an instrument factor, the so-called "index," which depends on the type of microscope and camera used.
William J. Hacker & Co., Inc. 3526

Shock Testing Machine—The development of a new shock testing machine for the drop testing of electronic devices and other fragile equipment up to 150 lb in weight is announced. The machine will find the fragility of the product itself and can also be used to test the ability of cushioning material to meet military and commercial specifications.
Hardigg Industries 3527

Magnetic Analysis—The Rototester will detect open-surface flaws of 0.004 in. or more in depth in magnetic or non-magnetic cold-drawn steel coiled wire up to 1 in. diameter. Utilizing the advanced eddy-current technique of inspection, the Rototester rotating-head mechanism mounts directly on the draw block, and the detector unit rotates around the drawn wire as it emerges from the die. At production speeds (approximately 200 ft per min) flaws 1 in. and longer are detected.
Magnetic Analysis Corp. 3528

Portable Ozone Recorder—Ozone concentrations are accurately measured and continuously recorded for permanent

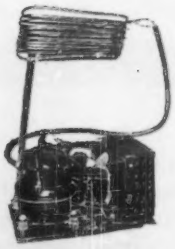
(*Continued on page 82*)

The CLOUD and POUR TEST CABINET with a future

Model 240—ASTM D 97

Three temperatures—three hermetic removable refrigeration units

Guaranteed for 3 years



*Moisture controlled heated top
*No valve to get out of adjustment
*Removal type sleeves

8 sleeves at plus 25–30 degrees
8 sleeves at Zero-plus 5 degrees
8 sleeves at minus 25–30 degrees

Other Models Available

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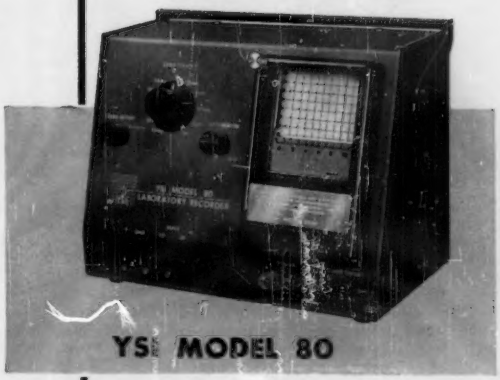

YSI MODEL 80

Operating Principle—Galvanometer with chopper bar pointer is clamped briefly for marking every two seconds.

Operating Ranges—Calibrated full scale deflections for 10 MV, 100 MV, 1 V, 10 V and 100 V and for 1 UA, 10 UA, 100 UA, 1 MA and 10 MA. Attenuator provides continuously variable adjustment between ranges and allows recording of up to 500 V or 50 Milliamperes full scale. Deflection sensitivities of from 200 microvolts per chart division to 10 volts per chart division and 20 milli-micro amperes per chart division to 1 milliamp per chart division.

Zero Offset—Continuous multiturn zero offset control allows zero left, zero center, or zero right operation and up to 4 times full chart width zero suppression in either direction on all ranges.

Ready to Record—Pressure sensitive paper requires no ink.

Recording Speeds—Standard instrument equipped to record at 1 and 15 inches per hour. Auxiliary gears available for 2, 3, 6, 10, 12 and 30 inches per hour.

Chart Characteristics—Chart width: 2.31 inches, chart divisions 50, chart length 63 feet. Readable to ± ½%.

Input Characteristics—1 Megohm input resistance on all voltage ranges.

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LABORATORY ITEMS

(*Continued from page 80*)

reference on a 6-in. strip chart with the MDC Model 725-3B portable ozone recorder. It is used in air pollution, industrial hygiene, weather, and agricultural studies. Further, it is used for test-chamber monitoring in the fields of rubber, elastomer, and similar material research.
Mast Development Co., Inc. 3529

V-Meter—This new instrument incorporates a single, adjustable control that provides the operator with instantaneous and continuous direct readout of velocity over a range from 2500 to 50,000 ft per sec for luminous hypersonic gas flow. The fast response of the V-meter's optical transducer allows accurate measurement of time intervals to 2 microsec.
MHD Research, Inc. 3530

Thermometer — Resistance thermometers for accurate sensing of temperature in weather-exposed as well as protected areas are available in the Model S29. Producing a positive change of resistance of more than 3 ohms for each deg C change in temperature, these thermometers are useful as remote or proximate detectors in temperature flashing signs and in industrial processing and control applications. Their completely potted construction in a filled epoxy case permits immersion in most gases and liquids.
Minco Products, Inc. 3531

Oscillograph—A low-cost direct-recording oscillograph designed for use in normal laboratory testing and evaluation is available. Known as the 1406 Visicorder, the new model produces instantly readable records of up to six channels of scientific and test data simultaneously.
Minneapolis-Honeywell Regulator Co. 3532

Tube Rack—An Italian-designed plastic finger holding principle permits full view of test tube contents in a new test tube rack. The rack, as well as the bases, are made of Nalgene, a laboratory-grade plastic that is unbreakable and chemically inert.
The Nalge Co., Inc. 3533

Yarn - Evaluating Apparatus — Large amounts of yarn can be tested for spinning defects, uniformity, and weaving qualities in an evaluation apparatus produced by a Dutch firm for use in textile spinning mills, knitwear factories, and weaving mills. A four-counter computer classifies the defects discovered and determines the numbers in each of four classes. The device permits the spinning defects to be cut off while simultaneously sorting them by classification.
Netherlands Trade Commission 3534

Liquid Extractor—A multistage mixer-settler liquid extractor for pilot plant solution of complex extraction problems has been announced. Features include: 20 discrete stages of 98+ percent efficiency; provision for sampling bath phases leaving each stage; provision for anti-soivent injection on each stage; feed rates up to 2 gal per hr; and built-in observation windows.
The Pennsylvania Tool & Mfg. Co. 3535

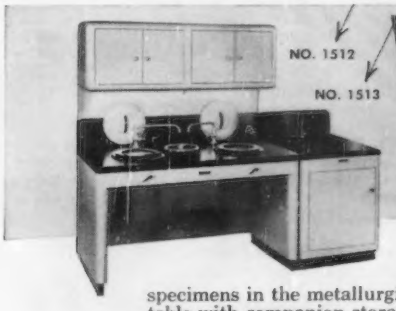
Radiography—The advent of high specific activity cobalt-60 (100 c per g and higher) has provided industry with a new radiographic tool. Model 60-1000 Gammatron, with a capacity of over 3000 c of cobalt-60, now provides 2-Mev radiography.
Radionics, Inc. 3536

Spectrum Analyzer—Three new Rayspan spectrum analyzers, each with 100 filters to analyze signals, have been announced. The Rayspan models, MRFR-30-5, 30-6, and 30-7, are capable of high-speed, high-resolution signal analysis. The new Raytheon units are an advance over the "sweeping-gate" analyzer with a single filter, which is limited to the analysis of relatively long-duration signals and steady-state phenomena. The three models operate in several bands within the 50 cps to 100 kc spectrum.
Raytheon Co. 3537

Bleeding Test—A test apparatus for determining the bleeding rate and bleeding capacity of cement paste and mortar is available for use in testing, research, and educational laboratories. CT-12 cement bleeding apparatus makes possible a direct and continuous reading of the bleeding rate of the test material. The test, intended for research only, conforms with ASTM Method C 243.
Soiltest, Inc. 3538

Tensile Testing—Compact, low-cost tensile testing machines having capacities up to 40,000 lb are now being made. These vertical, floor-mounted, motorized tensile testers are hydraulically operated, with the hydraulic system located within the base of the machine. Simple controls are conveniently mounted on the front of the base to ensure ease of operation.
Steel City Testing Machines, Inc. 3539

(*Continued on page 84*)



BUEHLER POLISHING DESK
...with matching storage cabinet...

For maximum efficiency in the production of specimens in the metallurgical laboratory the Buehler cabinet type polishing table with companion storage cabinets represents the latest modern development of this type of equipment.

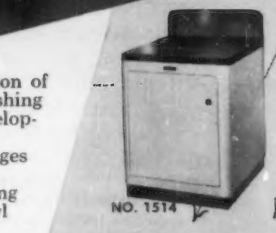
The convenience of this streamlined polishing equipment saves time and encourages the operator to produce the highest quality of polished sample.

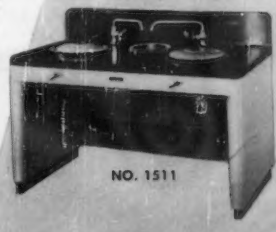
Item No. 1511 is a two-unit polishing table with Formica top approximately 60" long x 27" deep by 30" high to table top. Two 12" swing spouts, drain, 8" diameter wash bowl plumbing and wiring.

Recommended accessories to complete an efficient set up for maximum convenience are: No. 1512 storage cabinet with recessed light and No. 1513 supporting panel for installation above polishing desk. Or, No. 1514 floor model storage cabinet. Both these cabinets can be used together to advantage in most laboratories.

The Formica top and back on the table and cabinet is installed with a smooth Formica edge that eliminates all metal rims that may form pockets for water and dirt. Covers are held in place on the back by magnetic holders. The large 8" wash bowl is a new feature that enables the operator to use both hands in washing specimens.

All metal construction finished in hammer tone grey makes a very attractive appearance. Prompt delivery can be made on these new items.





The Buehler Line of Specimen Preparation Equipment Includes . . . Cut-Off Machines • Specimen Mount Presses • Power Grinders • Emery Paper Grinders • Hand Grinders • Belt Surfacers • Mechanical and Electro Polishers • Polishing Cloths • Polishing Abrasives

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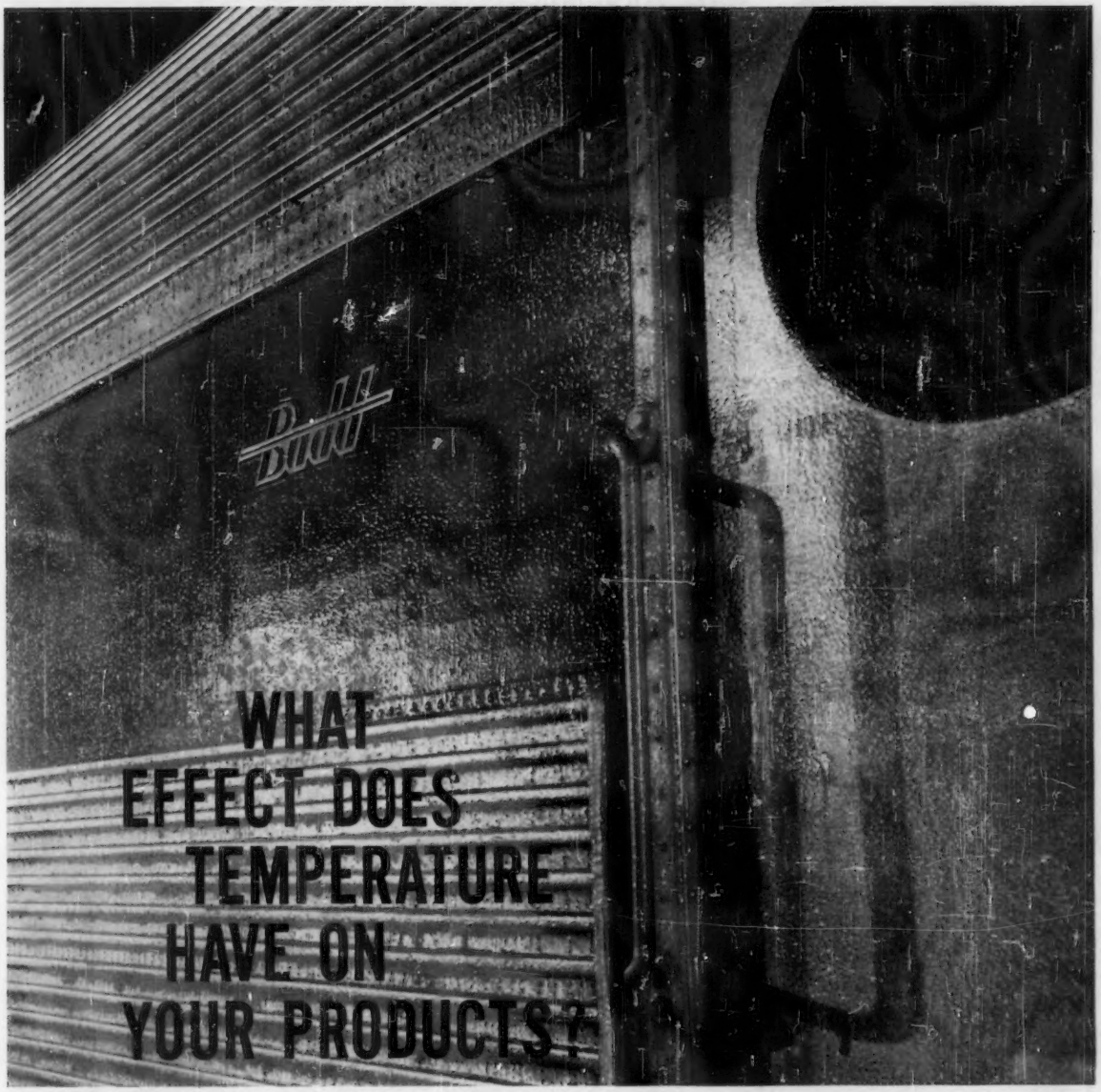

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Lowered recessed reading scale eliminates glare. Situated for maximum reading ease in line of vision with load pan.

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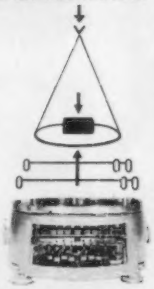
ANALYTICAL BALANCE

EXCLUSIVE
Monopan weights are in the bottom. Unlike other balances with weights on top, Monopan has no unnecessary swing. With Monopan, all downward force is compensated by equal upward thrust. Since weights are situated within the angle prescribed by pan, oscillation is minimized.



A single pan Analytical Balance making most efficient use of the reliable principle of substitution weighing for the determination of mass.

Very precise • Extremely stable • Remarkably simple.

Several exclusive features:

- Three position arrestment system provides positive locking of weight exchange in "free weighing" position.
- Load pan and substitution weights on separate stirrups minimize oscillation.
- Suspended side sliding doors. No dust-trapping grooves.
- No obstructive front corner posts.
- All controls at base. Operator can rest and steady forearm on table.

Cap.	200 grams
Tare Cap. (add.)	30 grams
Range of opt. scale	110 mg
Readability (per vernier div.)	0.1 mg
Accuracy diff. weighings within opt. range	0.03 mg
Size:	10½" x 18" x 18"
Net Wt.:	45 lbs.
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LABORATORY ITEMS

(*Continued from page 82*)

Puncture Tests—The Beach puncture tester was developed for the purpose of testing fiberboard, wall board, vulcanized fiber, thin plywood, very heavy paper, and similar materials. In specialized cases it has been used on asbestos board, plastic film, and rubber sheeting. The normal scale reading is from 0 to 1280 in-oz per in. of tear.

Testing Machines, Inc. 3540

Thermocouple Selector—Several newly designed rotary, key, and push-button selector switches for thermocouple and resistance thermometer applications are now being offered. These units provide rapid, accurate switching from 1 to 144 sensing elements.

Thermo Electric Co., Inc. 3541

INSTRUMENT COMPANY NEWS

Branson Instruments, Inc., Stamford, Conn.—In a recent expansion and diversification move, Branson Instruments, Inc., has acquired Colin Campbell Co., Inc., through exchange of stock. Also, by cash payment, Branson has obtained a half-interest in Radionics, Inc., Norristown, Pa.

Illinois Testing Laboratories, Inc., Chicago, Ill.—Fifty-year-old Chicago manufacturers of temperature, air, and dew-point indicating and controlling instruments, announces that in the future the firm will be called Alnor Instrument Co., Division of Illinois Testing Laboratories, Inc.

Morehouse Machine Co., York, Pa.—Producer of proving rings and other force-measurement instruments, has announced the formation of an Electronics Division. The new division, headquartered at the Morehouse plant in York, Pa., was formed through a merger with Applied Electronics, a York firm manufacturing metal detecting equipment and other industrial electronic controls. Charles W. Brister, owner of Applied Electronics, will assume the post of general manager of the new division.

MATERIALS NEWS

Solid Lubricants—The theory and practice of lubrication by solids are the primary subjects in a new booklet. The booklet discusses boundary friction and the role of solid lubricants to reduce friction and wear under heavy loads and at high temperatures. The 24-page, four-color booklet No. 124 describes the major advantages of molybdenum disulfide solid lubricants—low coefficient of friction, natural affinity for adherence to metal surfaces, and pressure resistance beyond the yield point of any metal.

Alpha-Molykote Corp., Stamford, Conn.

Epoxy Pipe Coating—Dearclad 765, a new epoxy pipe coating has been announced. It has a rapid curing rate, resistance to physical impact, abrasion, and moisture adsorption. The product provides protection against chemical attack, and has high electrical resistance. It retains its physical properties over the temperature range of −40 to 250 F plus.

Dearborn Chemical Co., Chicago, Ill.

Ultra-High-Strength Steel—A vacuum induction melted ultra-high-strength steel alloy S-110 has been developed for applications requiring high working stresses, such as railroad car springs, valve springs, and torsion bars. Utilizing high-grade raw material and close chemical control during induction vacuum melting, the resultant steel is free of many deleterious inclusions. Carbides are well distributed throughout the matrix with no evidence of carbide segregation present. ASTM Recommended Practice for Determining the Inclusion Content of Steel (E 45) is used to rate the steel. Complete detailed information on hardness, yield strength, rupture stress, etc. is available.

Kelsey-Hayes Co., New Hartford, N. Y.

Phosphor Bronze Handbook—An 18-page technical handbook on phosphor bronze has been issued. In addition to a detailed explanation of continuous castings the handbook includes information on phosphor bronze wire, bars, rods, strip, sheets, circles, and special shapes. Flexo-grain, a special fine-grain phosphor bronze, is also discussed in detail. Complete specifications on six of the phosphor bronze alloys are also given in an easy-to-read format.

H. K. Porter Co., Inc., Riverside-Alloy Metal Div., Riverside, N. J.

BOOKSHELF

(*Continued from page 75*)

designer of electrical devices rarely can foresee the behavior of the insulation under all service conditions, he must consult numerous specialized publications whose reliability is not always without question.

Much of the technical information available in the literature is in a form that is not useful to the designer. Weak points of insulating matrials are often described with caution to avoid bad publicity for a product, and materials of the same commercial designation may differ greatly in their properties. These drawbacks were clearly revealed several years ago when a committee of the International Electrotechnical Commission (IEC TC 2C) classified insulating materials according to their heat resistance. This term covers separately measurable chemical, mechanical, and electrical characteristics. But practical conclusions drawn from such measurements depend heavily on estimates. The reliability of this earlier tabulation for various thermal classes of insulators therefore was questionable.

The Swiss Electrical Committee decided to supplement and eventually to replace this tabulation of insulating materials according to thermal classes by a manual that would list the still only vaguely defined heat resistance together with the other properties of design value. The IEC supported this project in 1954 in Philadelphia, Pa., by delegating responsibilities for the manual's preparation.

(*Continued on page 87*)

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The easy modern way to determine exact working temperatures!

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ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

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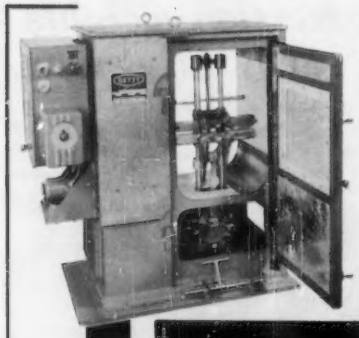

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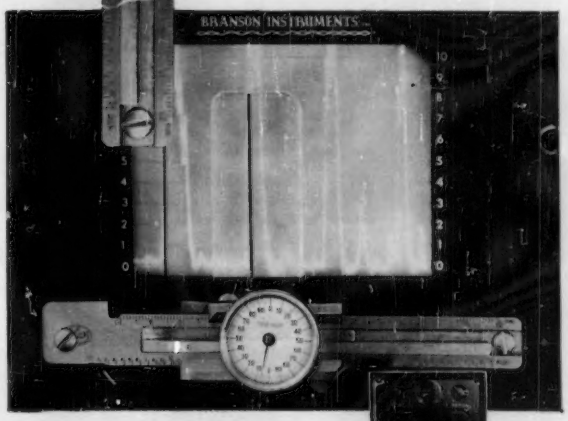

The *Sonoray*® Caliper permits direct readings of flaw-depth and workpiece-thickness with absolute accuracies of a few thousandths of an inch, the relative accuracy increasing with thickness. Thus the ultrasonic-pulse *Sonoray*®, pre-eminent for flaw detection, can now be used additionally for high-precision measurement of thickness.

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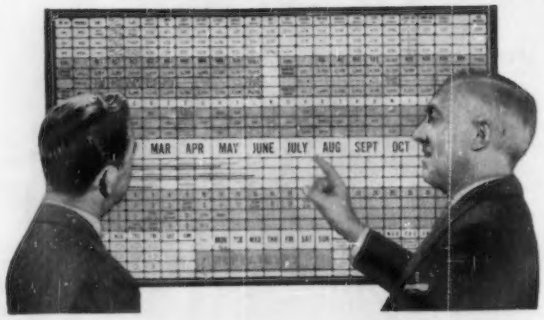

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- Made to your specifications as to *material* (brass, stainless steel, tantalum, etc.), *shape*, *size*, *finish* (plating in nickel, chromium, cadmium; brass lacquer; anodized aluminum).
- Metric, avoirdupois, troy (apothecary) systems.
- Send for complete information, including catalog of standard Troemner weights.

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STANDARD OF EXCELLENCE

CIRCLE 804 ON READER SERVICE CARD

(*Continued from page 84*)

The resulting encylopedia is divided into three parts: (*a*) general classification of insulating materials, (*b*) the synoptic tables of groups and descriptive sheets which present general properties and the characteristics which differentiate one group from another, and (*c*) monographs which describe the properties of each material. A provisional French edition of the first two parts was presented to the meeting of IEC in Vasteras, Sweden, in 1958, where a careful review was recommended, but its originality and simple presentation was approved.

The results of these efforts to date have now been published. The first two parts have been combined into a single document, and the French and German editions are now available. The English edition will be off the press shortly. This portion of the Encyclopedia of Electrical Insulating Materials is an easily accessible source of data on general physical and chemical properties of all materials suitable for a particular job. By listing conditions under which insulating materials may be used, their behavior in service, and necessary precautions, and by including a classification of materials, synoptic tables, and descriptions, this manual establishes an entirely new system of information and comparison. The monographs on the properties of each material are now in preparation.

Soils and Soil Engineering

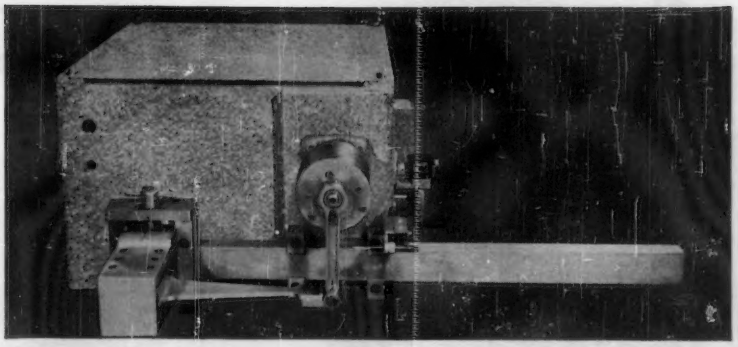
R. H. Karol; Prentice-Hall, Inc., Englewood Cliffs, N. J. (1960); 194 pp.; Illus.; $11.65.

Reviewed by L. C. Gilbert, ASTM Staff.

SOIL STABILIZATION and foundation design have become very important factors in the successful construction of building and highway structures. A structure is only as strong as the ground on which it stands. Mr. Karol as soils engineer for American Cyanamid Co. and as president of Karol-Warner, Inc., is well fitted to prepare and collect the very significant and useful information contained in this volume.

Sixteen chapters review and discuss the important phases, techniques, and properties of soils and soil engineering. Typical of the subjects covered are soil formation and distribution, physical properties of soils, consolidation, stability of slopes, piles and pile groups, soil stabilization, and chemical grouting. The last subject, chemical grouting, is of particular interest to soils engineers, it being a fairly recent development in the treatment of soils.

Mr. Karol has been an active member and contributor in the work of ASTM Committee D-18 on Soils for Engineering Purposes.



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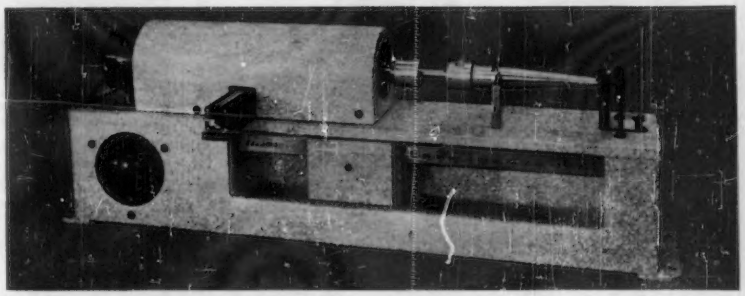

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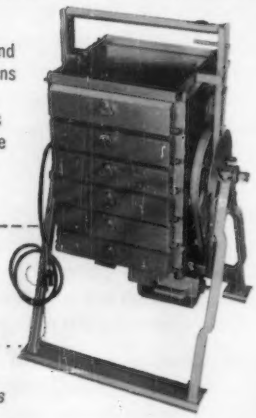

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October 29–November 2—**Federation of Societies for Paint Technology,** Annual Meeting, Hotel Sherman, Chicago, Ill.

October 31–November 2—**Society of Rheology,** Annual Meeting, Mellon Inst., Pittsburgh, Pa.

November 2–4—**Society for Experimental Stress Analysis,** Annual Meeting, Hotel Claremont, Berkeley, Calif.

November 3–4—**National Slag Assn.,** Annual Meeting, Hotel Mayflower, Washington, D. C.

November 9–11—**Annual Pittsburgh Diffraction Conference,** Mellon Inst., Pittsburgh, Pa.

November 14–16—**Steel Founders' Society of America,** Technical and Operating Conference, Carter Hotel, Cleveland, Ohio.

November 14–18—**National Electrical Manufacturers Assn.,** Annual Meeting Traymore Hotel, Atlantic City, N. J.

November 14–18—**American Society of Tool Engineers,** Western Tool Show and Semiannual Convention, Los Angeles, Calif.

November 15–17—Air Force-Navy-Industry Propulsion Systems Lubricants Conference; cosponsored by **ARDC, Wright Air Development Div.,** and **Southwest Research Inst.** Hilton Hotel, San Antonio, Tex.

November 16–19—**Society of Naval Architects and Marine Engineers,** Annual Meeting, The Waldorf Astoria, New York, N. Y.

November 27–December 2—**American Society of Mechanical Engineers,** Annual Meeting, Statler-Hilton Hotel, New York, N. Y.

November 28–30—**American Society of Refrigerating Engineers,** Semiannual Meeting, Chase-Park Plaza Hotels, St. Louis, Mo.

December 4–7—**American Institute of Chemical Engineers,** Annual Meeting, Statler Hotel, Washington, D. C.

December 5–7—**American Society of Agricultural Engineers,** Winter Meeting, Hotel Peabody, Memphis, Tenn.

December 5–9—**National Conference on the Application of Electrical Insulation,** Conrad Hilton Hotel, Chicago, Ill.

December 12–14—**Building Research Inst.,** Fall Conference, Shoreham Hotel, Washington, D. C.

December 12–15—**Industrial Building Exposition and Congress,** New York Coliseum, New York, N. Y.

December 12–15—**American Nuclear Society,** Mark Hopkins Hotel, San Francisco, Calif.

December 14–16—**Atomic Industrial Forum,** Annual Conference, Fairmont Hotel, San Francisco, Calif.

December 26–31—**American Association for the Advancement of Science,** Annual Meeting, New York, N. Y.

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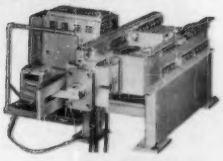

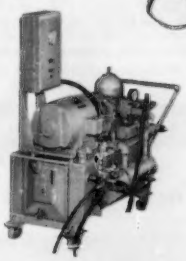

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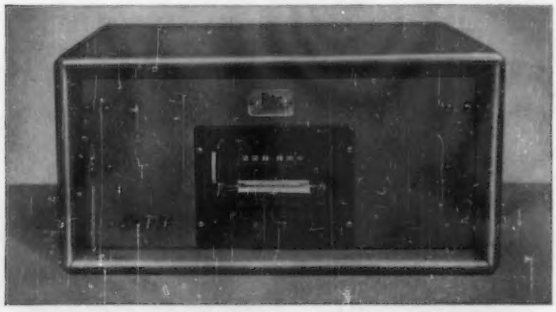

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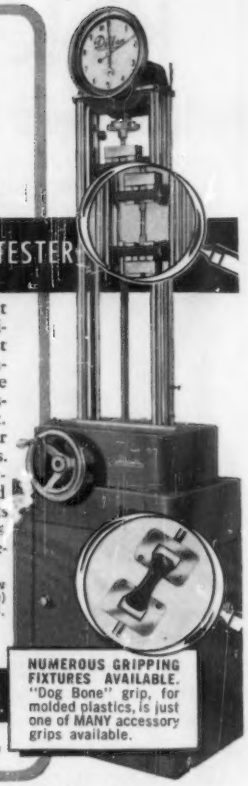

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Federal Government Standards Index Changes

THE FEDERAL Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for Procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplement 5 for July, 1960.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity.
Cement, Hydraulic Sampling, Inspection and Testing	Rev.	Fed. Test Method Std. 158a	5611	COM-NBS
Color of Painted Metal General Office Furniture	Rev.	Fed. Std. No. 124a		GSA-FSS
Identification of Feathers and Down	New	Fed. Std. No. 148	8320	DOD-Army-QMC
Buret, Straight	New	DD-B-790	6640	DOD-Navy-MMSA
Cloth, Cotton, Ticking, Twill	Int. Am. 1	CCC-C-436	8305	DOD-Army-QMC
Cloth, Wire, Industrial	Rev.	RR-C-440	5335	DOD-Navy-WEPS
Copper, Ingots	Int. Am. 1	QQ-C-521b	9650	DOD-Navy-Ships
Molding Plastic, Polystyrene	Rev.	L-M-520	9330	DOD-Navy-Ships
Molding Plastic, Poly(Vinyl Chloride), Rigid	Rev.	L-M-530	9330	DOD-Navy-Ships
Test Glass, Sedimentation	New	DD-T-185	6640	DOD-Army-CmlC
Waste, Matted Yarns (Cotton Colored)	Rev.	DDD-W-101b DDD-W-00101a (GSA-FSS)	9450	DOD-Army-QMC
Zinc, Slab (Spelter)	Int. Am. 2	QQ-Z-351a	9650	DOD-Navy-Ships

WITHDRAWALS

Title	Type of Action	Symbol or Number	Assigned Agency	Reason for Withdrawal
Color of Painted Metal General Office Furniture	Am. 1	Fed. Std. No. 124	GSA-FSS	To be issued as revised Fed. Std.
Drums, Metal, 55 and 110 gal (for Flammable or Poisonous Liquids)	Rev.	PPP-D-726	COM-BDSA	Survey by Commerce indicates material no longer purchased by the Gov't.
Drums, Metal, 55 and 110 gal (for Flammable Solids or Oxidizing Materials)	Rev.	PPP-D-741	COM-BDSA	Survey by Commerce indicates material no longer purchased by the Gov't.
Rubber, Cellular, Latex Foam	New		COM-NBS	Project relinquished by NBS

PROMULGATIONS

Title	Type of Action	Symbol or Number
Aluminum Alloy Bars, Rods, and Shapes, Extruded, 3003 (Superseding QQ-A-357)	Rev.	QQ-A-357a
Aluminum Alloy Bars, Rods, and Wire, Rolled, Drawn, or Cold Finished, 3003 (Superseding QQ-A-356c)	Rev.	QQ-A-356d
Butyl Alcohol, Normal (Butanol) (for use in Organic Coatings) (Superseding TT-B-00846a (GSA-FSS) & TT-B-846)	Rev.	TT-B-846b
Cable, Power, Electrical, (Rubber-Insulated, Building-Type) and Wire, Electrical (Rubber-Insulated, Building-Type) (Superseding J-C-00103a(COM-NBS) & J-C-103)	Rev.	J-C-103b
Diamyl Phthalate, Plasticizer (for use in Organic Coatings (Superseding TT-D-00291a (GSA-FSS) & TT-D-291)	Rev.	TT-D-291b
Enamel, Odorless, Alkyd, Interior, Semi-Gloss, White, and Tints (Superseding TT-E-00509 (Army-CE)	New	TT-E-509a
Filler, Wood, Paste	Am. 1	TT-F-336b
Funnel, Common, Laboratory, Fluted or Ribbed (Superseding DD-F-00796a (GSA-FSS) & DD-F-796)	Rev.	DD-F-796b
Funnel, Common, Laboratory, Smooth (Superseding DD-F-00806a (GSA-FSS) & DD-F-806)	Rev.	DD-F-806b[1]
Insulation Board, Thermal, Cork (Superseding HH-C-561b)	New	HH-I-525
Methanol (Methyl Alcohol) (Superseding O-M-00232c (Army-CE) & O-M-232b)	Rev.	O-M-232d
Paper, Book	Am. 2	UU-P-465c
Paper, Duplicating, Copy, Liquid Process	Am. 2	UU-P-232a
Paper, Kraft, Untreated, Wrapping (Superseding UU-P-00268d (Army-QMC) & UU-P-268c)	Rev.	UU-P-268e
Paper, Mimeograph	Am. 2	UU-P-388h
Paper, Teletypewriter, Roll (Superseding UU-P-547f)	Rev.	UU-P-547g

(Continued on page 94)

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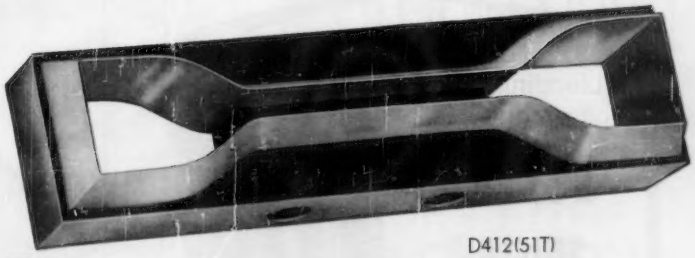

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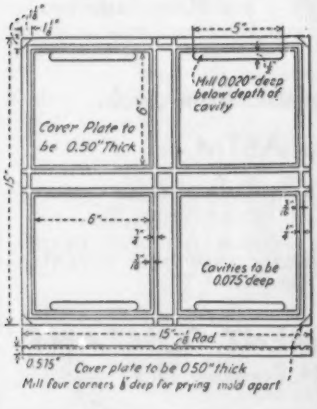
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CIRCLE 817 ON READER SERVICE CARD

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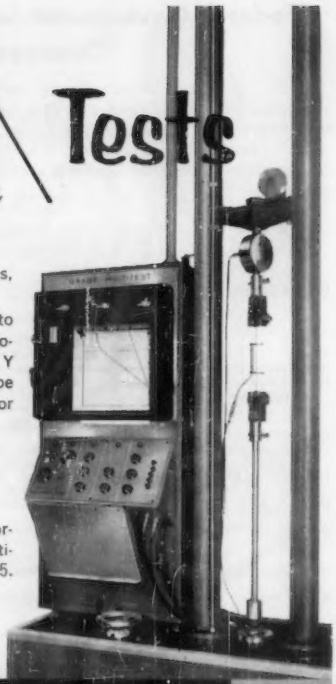
Bending
Oscillation

Tests



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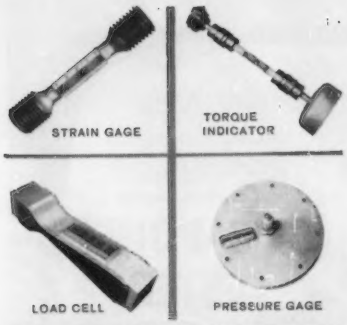

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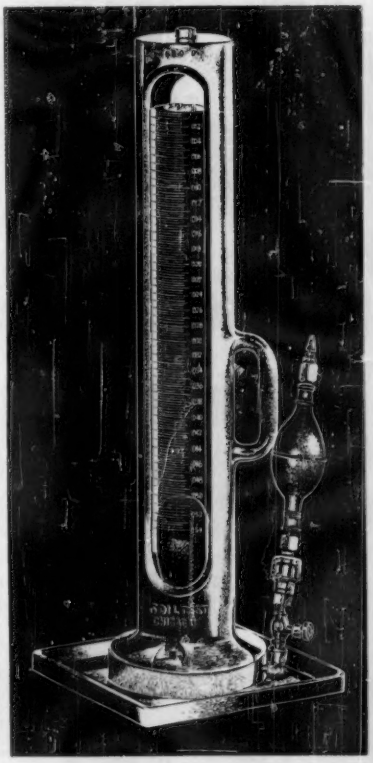

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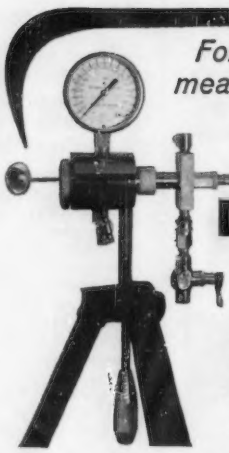

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Paper, Wrapping, Wet-Waxed (Superseding UU-P-134a)	Rev.	UU-P-134b
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Steel, Sheets, Carbon, Zinc-Coated (Superseding QQ-S-755 (Navy-Ships) & QQ-I-716)	New	QQ-S-775a
Sulfuric Acid, Technical (Superseding O-S-809 (GSA-FSS) & O-A-115)	New	O-S-809a
Tape, Electric Wire—Flexible Insulating Sleeving Marking Machine (Foil, Wire Identification, Marking)	Am. 1	QQ-T-25
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Thread, Linen (Superseding V-T-291b)	Rev.	V-T-291c
Tube, Aluminum Alloy, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless, 1100 (Superseding WW-T-783b)	Rev.	WW-T-783c
Tube, Aluminum Alloy, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless, 3003 (Superseding WW-T-788b)	Rev.	WW-T-788c
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Wire, Electrical and Nonelectrical, Copper, (Uninsulated) (Superseding QQ-W-338a, QQ-W-339, & QQ-W-341a)	New	QQ-W-343
Wire Rope and Strand (Superseding RR-W-00410 (Navy-Ships) & RR-R-571a (in Part))	New	RR-W-410a
Wire, Steel, Alloy (for Cold Heading and Cold Forging) (Superseding QQ-W-00405 (GSA-FSS) & QQ-W-403)	Rev.	QQ-W-405a
Zinc Coating Electrodeposited, Requirements for	Am. 1	QQ-Z-325a

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Paper, Toilet Tissue	Rev.	UU-P-556
Pigments-In-Oil, Tinting Colors	Rev.	TT-P-381
Tape, Paper, Computing-Machine	Rev.	UU-P-185
Antiseize Compound, White Lead Base, General Purpose (for Threaded Fittings)	Rev.	TT-A-530a
Bottle, Narrow and Wide Mouth, with Ground Glass Stoppers	Rev.	DD-B-593a
Dishwashing Compound, Hand (Neutral Synthetic Detergent, Solid Form)	Am. 1	P-D-410
Drums, Metal, 55-gal (for shipment of Noncorrosive Material)	Am. 1	PPP-D-729b
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Molding Plastic, Cellulose Acetate	Am. 2	L-M-505
Molding Plastic, Polystyrene	Am. 3	L-M-520
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Paper, Map (Lithographic-Finish)	Canc.	UU-P-361a
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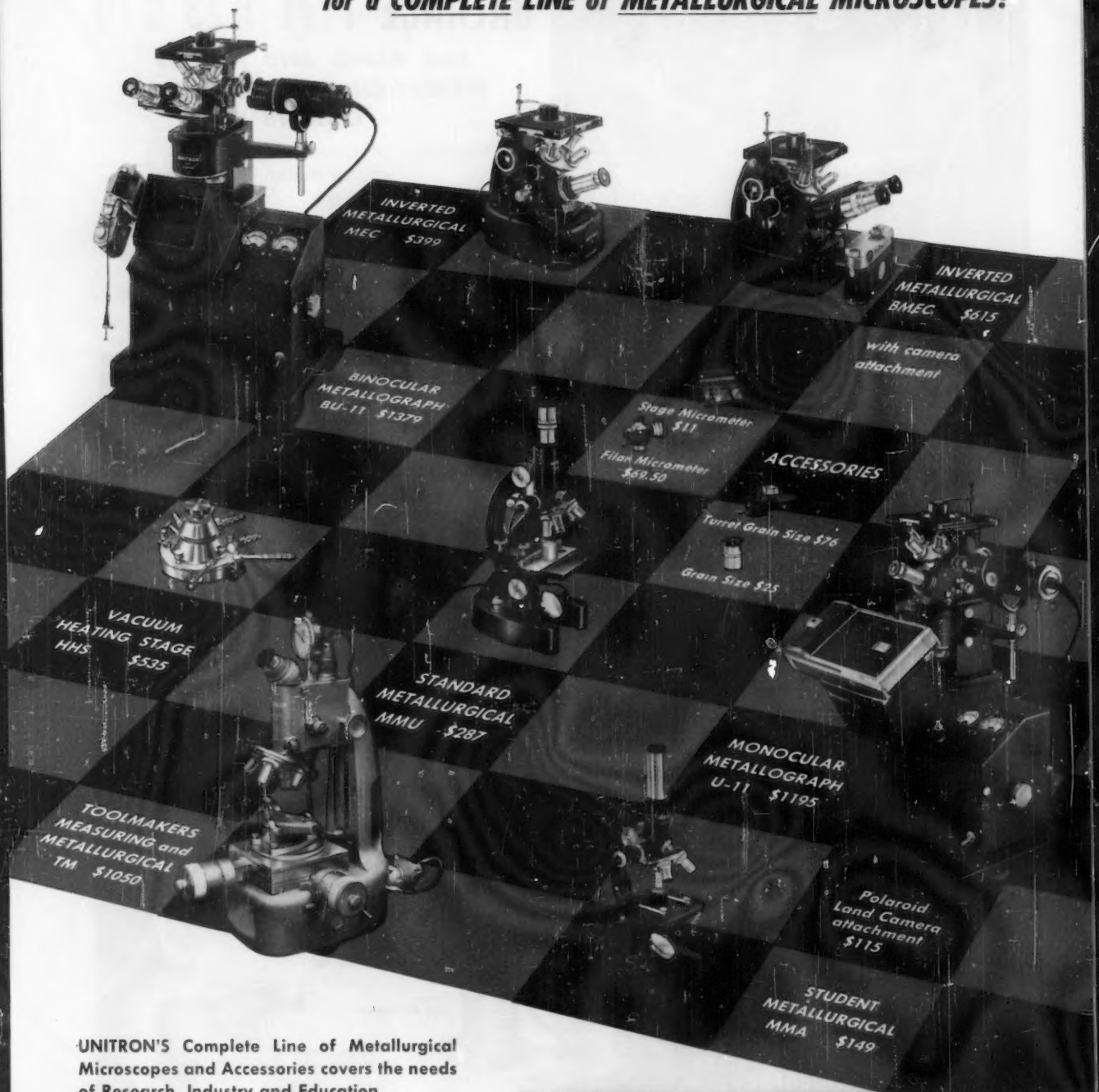

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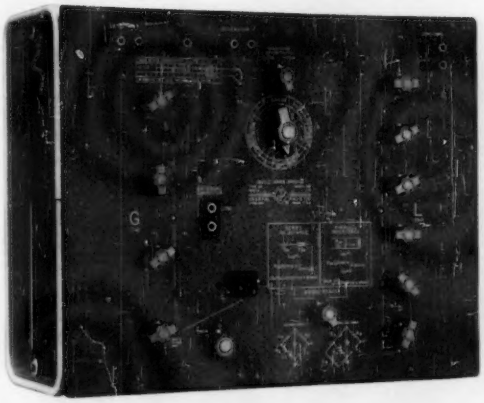

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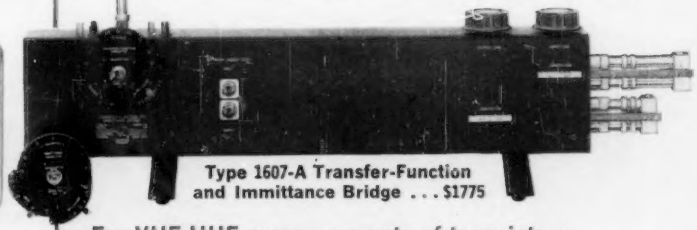

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